POWER PLANT ENGINEERING

Established Over 32 Years

VOL. XXXII CHICAGO, FEBRUARY 1, 1928 No. 3

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Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.
Copyright 1928, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this Issue 23,350

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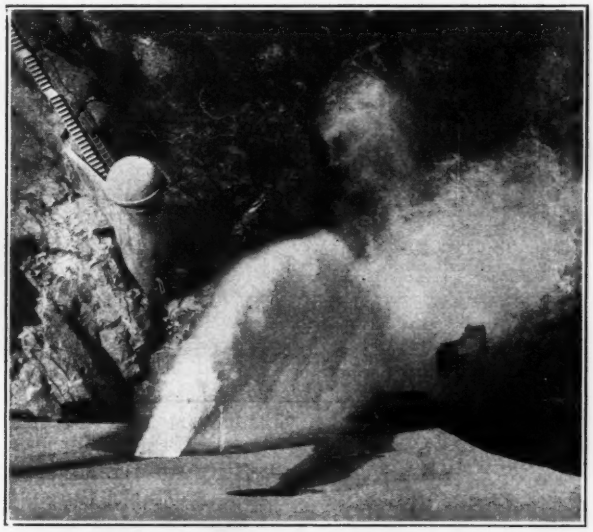


"Quick, Watson, the Needle!"

YOU MAY think to yourself, on looking at the above picture, that the needle has already been applied. This might be a scene from one of these modernistic cinematic masterpieces that our Teutonic friends insist mean something darkly symbolic and Freudian—crazy stairways, sloping walls and futuristic little round-topped house at the left where lives the hero of the piece.

But, although the above picture does not happen to be taken from the works of UFA, it is nevertheless a fact that the needle has been applied—to the dam, however, and not to the photographer. The hydrodermic needle, if we may be pardoned. For you are now looking straight down the face of a large dam through which a 5-ft. needle valve is discharging.

But, you may ask, how do the designers of the dam know how many of these needle valves will be needed in a given case? Well, most of this water starts as melting snow up in the mountains. So if they can get some idea during the winter of how much snow is likely to melt in the spring and run down to fill the reservoirs, they have something definite on which to base their designs. Such an estimate can be made, although not without considerable difficulty; the men who do this work are known as hydrographers. You may be interested in reading elsewhere in this issue about some of the winter trips of the San Joaquin Light & Power Corp. hydrographers.

Fisher Body Corporation Burns Sawdust and Coal at Flint

NEW POWER PLANT SUPPLIES STEAM, COMPRESSED AIR, HOT WATER HEAT AND OTHER SERVICES; THREE STOKER-FIRED BOILERS ARE USED AND THREE BURNING SAWDUST AND PULVERIZED COAL

SUPPLYING STEAM AND compressed air to the industrial processes of Flint Unit No. 1, Fisher Body Corp., Flint, Michigan, the new power plant described in this article burns both coal and sawdust, is well arranged for convenience and safety and has given extremely economical operating results. No power is generated in this plant, instead it is purchased from the Consumers Power Co.

Six boilers are installed, three of them fired by coal burned on underfeed stokers, the other three fired by sawdust or pulverized fuel, both burned in suspension. Three steam-driven air compressors and one motor-driven air compressor supply air for factory work. One of the principal features is the fuel handling system for both sawdust and coal.

The boiler house supplies steam for paint ovens, heating system, steam-driven air compressors and dry kilns. Steam is generated at 200 lb. and supplied to the steam-driven air compressors and auxiliary turbines. It is sent to the mill at 125 lb. through tunnels. Steam for the dry kilns is taken at 22 lb. from the exhaust of 6 small steam engines driving fans on the sawdust collecting systems in the industrial departments. Live steam for the kilns is taken from the 125-lb. lines through reducing valves to make up any deficiency of exhaust steam. This battery of dry kilns will hold 1,000,000 bd. ft. of lumber, uses 24,000 lb. of steam an hour and possesses several interesting features that are beyond the scope of this article.

Steam is generated at 200 lb. gage pressure in 6 straight-tube, cross-drum water tube boilers set in two rows of three each on either side of the central firing aisle, as shown in Fig. 3 and in the headpiece. Each boiler has 7220 sq. ft. of heating surface and generates saturated steam, no superheaters being included. Econ-

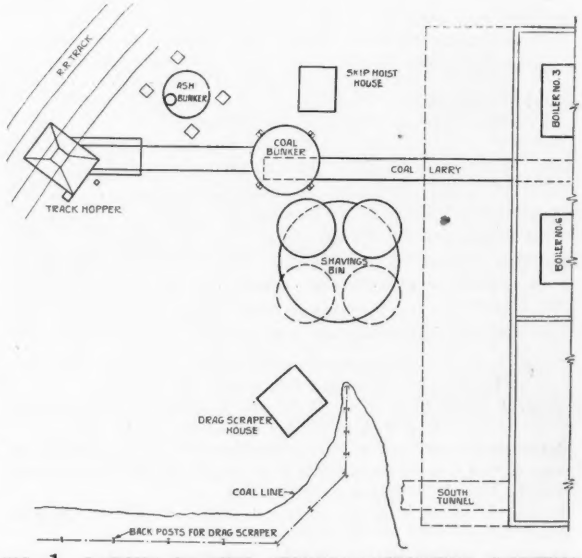


FIG. 1. LAYOUT OF FUEL STORAGE EQUIPMENT, SHOWING COAL, ASH AND SAWDUST TANKS

omizers and air preheaters are not installed, although the air-cooled setting of the three sawdust and pulverized coal boilers preheats the combustion air as will be explained below. These three boilers and the three

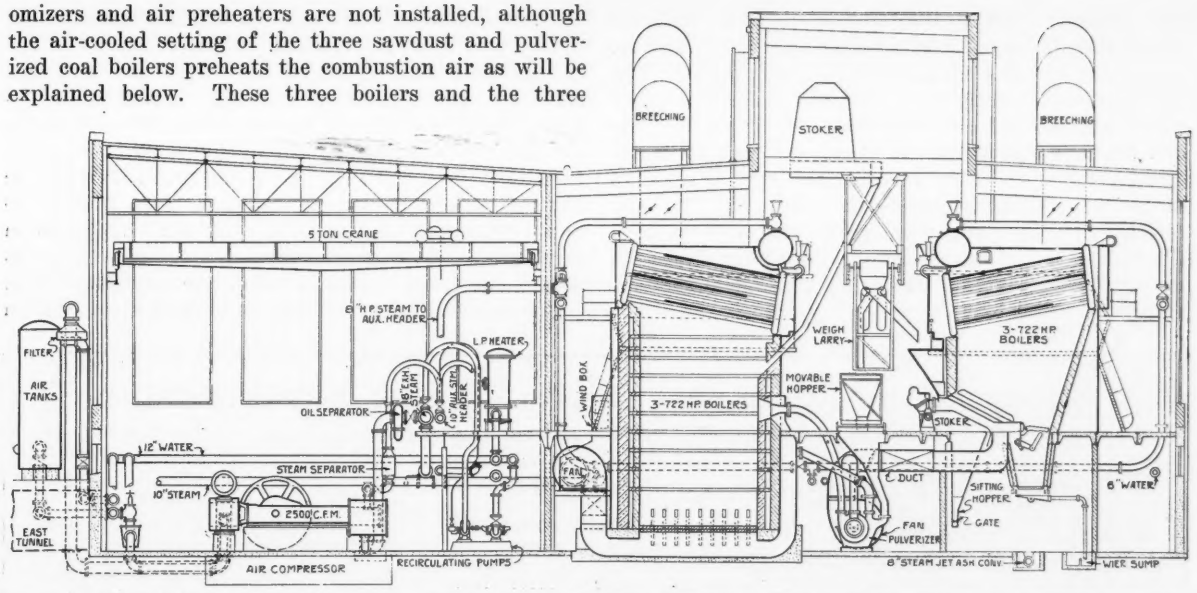


FIG. 3. CROSS-SECTION THROUGH PLANT, SHOWING STOKER-FIRED BOILERS, SAWDUST OR PULVERIZED COAL FIRED BOILERS AND COMPRESSOR ROOM LAYOUT

stoker fired units are horizontally baffled as shown, for two passes. Boilers are set singly, with plenty of room on all sides of each. A mezzanine floor just below the rear tube levels, on both sides and one end of the room, gives access to boiler tubes, water columns and valves. Each boiler is equipped with a steam purifier, installed in the drum, the discharge from these purifiers being trapped out. Inclined water gages are provided which can be readily observed from the firing floor. Feed water regulators control the boiler water level and an automatic combustion control system adjusts fan and stoker speeds on the stoker-fired boilers. On the other three boilers, controls for unit pulverizers, wood stokers and fans are provided on the firing floor at each boiler, together with draft and pressure gages and indicating steam flow meters.

Three boilers, Figs. 3 and 4, are set with seven-retort underfeed stokers, each driven by a 4¼ by 5-in. vertical steam engine, controlled by the automatic combustion control system. Settings are solid refractory, without

FIG. 2. THREE UNIT PULVERIZERS AND TWO FORCED DRAFT STOKER FANS ARE SET BETWEEN BOILERS IN BASEMENT

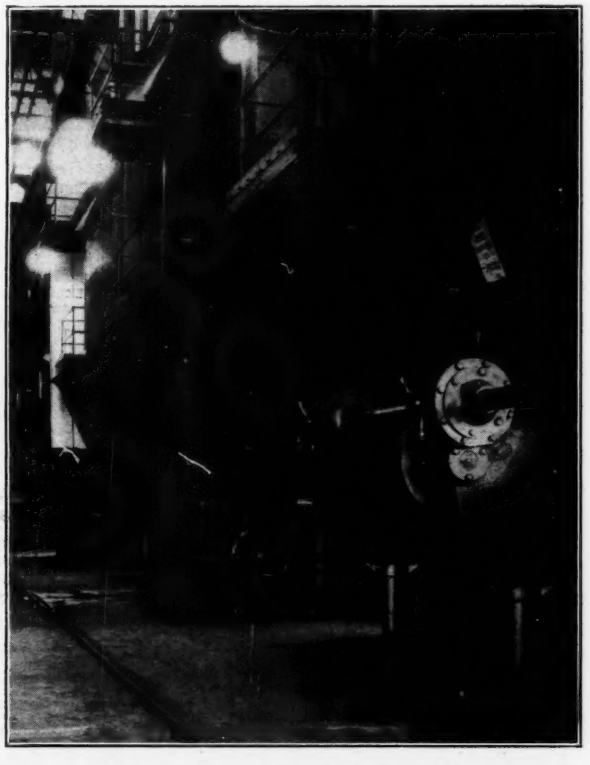


FIG. 4. THREE 7-RETORT UNDERFEED STOKERS ARE DRIVEN BY STEAM ENGINES, GOVERNED AUTOMATICALLY

any artificial cooling and are designed so that the boilers operate normally at about 200 per cent of rating. The stoker dumps drop ash into hoppers equipped with quenchers and hydraulically operated ash gates. After quenching, ash is dropped from the hoppers to the floor and fed into a steam jet ash conveyor. This is located directly under the hoppers and discharges to a hollow tile ash storage tank outside the plant, Fig. 5. Ash hoppers and conveyor are separated by a partition from the rest of the basement and the quenching of the ash in the hopper prevents dust when feeding to the conveyor.

Three Boilers Use Wood Waste or Pulverized Coal

The other three boilers are set with furnaces designed for burning either pulverized coal, shavings or sawdust. It is not planned to burn them in combination owing to the difficulty of introducing air at the proper point for both fuels at once. Sawdust, fed by the sawdust stokers above the boilers is brought down to each furnace by four chutes, as shown and burns in suspension. A turbulent type pulverized coal burner is set in the front wall just below the sawdust chutes, pulverized coal being fed to these burners directly from

Principal Equipment in Flint Unit No. 1 Fisher Body Corporation

BOILER AND COMBUSTION EQUIPMENT

Boilers ..... Heine Boiler Co.
Number 6
Heating surface sq. ft. 7220
Steam pressure ..... 200 lb.
Boiler Settings—
For wood and pulverized coal ..... Combustion Engrg. Corp.
Type ..... 3 Lopulco air cooled
For stokers ..... 3 Solid refractory
Arches ..... Bigelow Arch Co.
Firebrick ..... Walsh Fire Clay Prod. Co.
Stokers ..... American Engineering Co.
Type ..... Taylor 7-retort
Number 3
Drive ..... 3 Troy steam engines 4¼ by 5 in. each
Stokers ..... Allington & Curtis Mfg. Co.
Type ..... Sawdust burning
Number 3
Drive ..... E. H. Wachs Co. steam engines, each 4½ by 6 in.
Coal Pulverizers ..... Combustion Engineering Corp.
Type ..... Raymond unit type
Number 3
Capacity ..... 5000 lb. an hour each
Drive ..... 60 hp., G.E., 3 ph., 440 v. motor
Pulverized Coal Burners ..... Combustion Engineering Corp.
Type ..... Couch, turbulent, water cooled
Number 3

FUEL AND ASH HANDLING EQUIPMENT

Coal Handling System ..... R. H. Beaumont Co.
Drag scraper, capacity ..... 40 t. per hr.
Crusher, capacity ..... 40 t. per hr.
Automatic skip hoist, capacity. 40 t. per hr.
Steel storage tank ..... 75 t.
Weigh larry ..... 2000 lb.
Movable hopper ..... 1½ t.
Sawdust Conveying System ..... Mahon Structural Steel Co.
Fans ..... Buffalo Forge Co.
Fan Drives ..... Troy Engine & Mach. Co. engines
Ash Hoppers and Gates ..... Allen-Sherman-Hoff Co.
Steam Jet Ash Conveyor and Tile Ash Storage Tank ..... United Conveyors Corp.

METERS AND INSTRUMENTS

Main Switchboard ..... Trumbull Elec. Co.
Steam Flow Meters and Air Flow Meters, electric (G.E.) ..... Bailey Meter Co.
Draft Gages ..... Lewis M. Ellison
Recording and Indicating Thermometers and Pressure Gages, Pyrometers, etc. ..... Taylor Instrument Cos.

Note: All motors driving auxiliaries are 3-phase 440-v. units.

FANS AND DRAFT EQUIPMENT

Forced Draft Fans....	Buffalo Forge Co. Stok. boil.	P.C. boil.
Number	2	3
Type and size	1 No. 7, 1 No. 7½	3 No. 7
Drive	1-75 hp. Terry Turbine	3-25-hp.
	1 75-hp. G. E. Motor	G. E. Motors.

Boiler Breechings ..... H. W. Hawley Co.
Chimney ..... H. R. Heinicke Co.
Number ..... 1 radial brick
Size ..... Dia. 17 ft., height 365 ft.
Combustion Control System ..... A. W. Cash Co.

BOILER ACCESSORIES AND MECHANICAL EQUIPMENT

Feed Water Regulators ..... (Copes) Northern Equipment Co.
Soot Blowers ..... Bayer Co.
Steam Traps ..... Armstrong Machine Works
Water Columns and Inclined Water Gages ..... Wright-Austin Co.
6 Tracyfiers and Traps ..... Andrews-Bradshaw Co.
Valves—
Steam and water ..... Jenkins Bros.
Blowoff and safety ..... Crosby Steam Gage & Valve Co.
Non-return and atmospheric relief. ..... Schutte & Koerting Co.
Pressure reducing ..... A. W. Cash Co.
Pipe Covering ..... Philip Carey Co.
Uptake and Breeching Linings ..... Johns-Manville, Inc.
Piping ..... Murray W. Sales Co.
Power House Crane, 5 t. ..... H. D. Conkey & Co.
Locomotive Crane ..... Industrial Works
3-6 in. Steam Separators. Hoppes Mfg. Co.
3-12 in. Oil Seperators ..... Illinois Engineering Co.

BOILER FEED AND OTHER PUMPS

Boiler Feed Pumps ..... Buffalo Steam Pump Co.
Number 3
Capacity ..... 300 g.p.m. each, 565-ft. head
Drive ..... 2 Terry turbines, type 22, 80 hp., 1750 r.p.m. 1 G.E. 100 hp., 3-ph., 440-v., 1750-r.p.m. motor
Condensation Pumps ..... Nash Engrg. Co.
Number ..... 2, Jennings-Hytor
Capacity ..... 200 g.p.m. each
Drive ..... G.E. 15-hp. motor
Fire Pumps ..... Buffalo Steam Pump Co.
Number ..... 2, Underwriters, type M, size 8, centrifugal
Capacity ..... 1500 g.p.m. each
Drive ..... 3 Kerr turbines, 150 hp. ea., exhausting to atmos.
Hot Water Circulating Pumps ..... Economy Pumping Machinery Co.
Number. 4, single stage for heating system
Drive ..... 75-hp. Moore single-stage steam turbines
Tank Pump ..... Buffalo Steam Pump Co.
Number ..... 1, centrifugal 3 in. for sprinkler service tank
Drive ..... 25-hp. G.E. motor
Sump Pumps for Coal Pit ..... Buffalo Steam Pump Co.
Water Storage Tanks ..... Pittsburgh-Des Moines Steel Co.
Number ..... Two, 200,000 gal. each

AIR COMPRESSORS

Air Compressors ..... Ingersoll-Rand Co.
Number ..... 3, Imperial, Type XPXR
Capacity each ..... 2500 c.f.m. at 100 lb. delivery pressure
Drive ..... Steam, 200 lb. pressure
Air Compressors. Sullivan Machinery Co.
Number ..... 1 Angle-Compound type WJ. 4
Capacity ..... 2250 c.f.m. at 100 lb.
Drive ..... 425-hp. G.E. Synchr. motor, 400-v., 257 r.p.m.
Air Compressor ..... Sullivan Machinery Co.
Number ..... 1, Type W.G., 6 by 6 in.
Drive ..... 17.5-hp. G.E. motor
Aftercoolers ..... Schutte & Koerting Co.
Number ..... 4, No. 10
Air Filters ..... Staynew Filter Corp.
Number 4
Capacity, each ..... 3000 c.f.m.
Air Receivers ..... Kewanee Boiler Co.

WATER HEATING AND TREATING EQUIPMENT

Water Softeners ..... Paige & Jones Chemical Co., Inc.
Type ..... 2 unit, zeolite
Capacity ..... 120,000 gal. per hr.
Feed Water Heaters. The Hoppes Mfg. Co.
Number ..... 2, Class R, Size E
Size ..... 5000 hp. each
Storage Tank ..... 72 in. by 24 in.
Water Heaters ..... Alberger Heater Co.
Number ..... 4 for forced circ. h.w. system
Type ..... Type H, vertical, 2 high press., 2 low press.
Storage Heater ..... O. E. Frank Heater & Engrg. Co.
Number ..... One, 900 gal. per hr.
Sylphon Regulators ..... The Fulton Sylphon Co.

Forced draft is supplied to these stokers by two forced draft fans located on the boiler room basement floor, between the boilers, where the unit pulverizers are also located, as shown in Fig. 2. The fans are connected to a duct running in front of the boilers, suitable windbox connections being taken off for each stoker. A combustion control system controls the speed of these fans and of the steam engines driving the three underfeed stokers.

the unit mills in the basement below. The furnaces for these three units are of the air-cooled type, the air passages and fan locations being as shown in Fig. 3. Each boiler has its own fan, connected to the ducts as shown, with a bypass in the duct around each fan.

When burning pulverized coal the air is drawn by the fan through the side walls of the air-cooled setting and supplied to the boiler as the secondary air. Another duct takes some of this air to the casing of the

pulverizer, partly drying the coal as it passes through to the primary air fan. The air is heated to about 170 deg. F. When burning sawdust or shavings the fan is by-passed and the ducts to the pulverizer and burner closed off. Air is then drawn by natural draft through the side walls and discharged into the furnace through the ports near the bottom. This aids in the burning of the heavier particles which do not burn in suspension.

By air cooling the walls, it has been found possible to use ordinary refractories, as the wall temperatures are reduced to a point below that at which the fusion, due to the alkalies in the wood ash, takes effect.

It has been found that the heat of the wood fuel burning at the mouths of the chutes just above the pulverized coal burner caused some warping of the parts of this burner. This trouble has been entirely eliminated by installing a burner with a water-cooled ring where it enters the furnace.

Fuel Handling Arrangements

Fuel handling arrangements at the Flint plant, as shown in the illustrations, are compact and flexible and at the same time furnish large storage capacity, as shown in Figs. 1 and 5. Savings and sawdust are collected by an exhausting system, with steam engine driven fans at suitable points in the mill. The exhaust from these engines at 22 lb. pressure goes to the dry kilns, being supplemented by the necessary live steam. The shavings and sawdust are sent to the large steel tank just outside the power house, and thence are delivered by another fan to the wood burning stokers above the boilers.

Coal is unloaded from the cars and distributed or reclaimed in the storage space by the drag scraper. It can be loaded into the skip hoist hopper either direct from the cars or by the drag scraper reclaiming from storage. The skip hoist loads the 75-t. steel storage tank, from the bottom of which a weigh larry can take it. The weigh larry runs through the covered enclosure into the boiler room, where it discharges either into the stoker hoppers or into the movable hopper feeding the unit pulverizers in the basement below.

Feedwater Supply

Feedwater makeup is obtained from two city water mains, one entering on each side of the plant. This water is softened, in a two-unit zeolite softener of 120,000 gal. per hr. capacity. The initial hardness of the water is 19-21 gr. and it is softened to 0-2 gr. hardness. The makeup required is about 110,000 gal. per 24 hr. All returns from the industrial processes, such as the dry kilns are brought back to a receiving tank, whence they are pumped to the 200,000-gal. storage tank on the tower. In this tank the discharge pipe runs half way up so that 100,000 gal. are always left in the tank for emergency fire and sprinkler service. Another 200,000 gal. tank at the base of this tower is kept filled direct from the city mains and the fire pumps and service pumps take suction directly from this tank under normal conditions. From the overhead tank, water is drawn through two 5000-hp. open feedwater heaters and fed to the boilers by three centrifugal pumps, two turbine driven and one motor driven.

Heating of the buildings is by a forced circulation hot water system, using two low pressure and two high pressure heaters installed as shown, in the compressor room. Exhaust from compressors and turbine driven auxiliaries supplies steam to the low pressure heaters and the feedwater heaters. Main steam headers and feedwater supply lines in the boiler room are of loop design and the piping for the hot water system heaters is centralized in front of them, the various circulating and service pumps being located below to give good piping connections.

All motors driving auxiliaries in the plant are designed for 60 cycles, 3-phase, 440 v. By proper proportioning of steam and motor drives, sufficient exhaust is ordinarily obtained for the heat balance requirements.

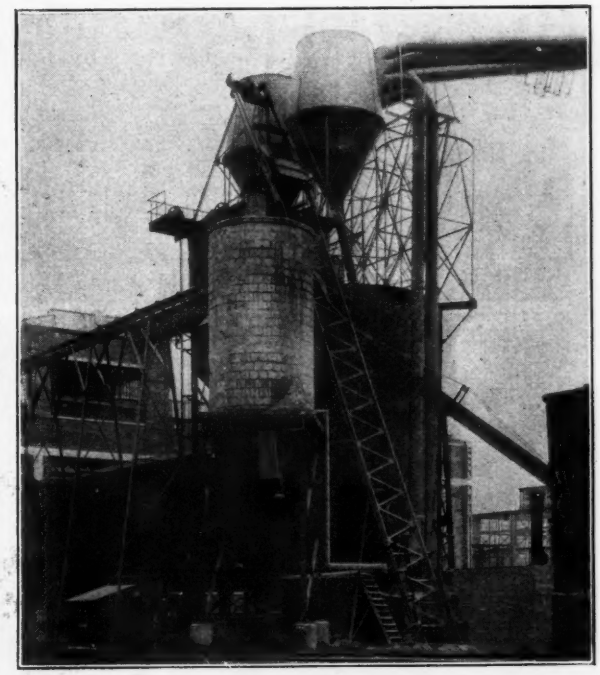


FIG. 5. CLOSE-UP VIEW OF FUEL AND ASH HANDLING TANKS, SHOWING WEIGH LARRY ENCLOSURE

Compressor Installation

In the compressor room are four compressors, three steam driven units of the cross-compound reciprocating engine driven type, each of 2500 c.f.m. capacity; the fourth unit is an angle compound compressor of 2250 c.f.m. compressor, driven by a synchronous motor, which is used primarily for power factor correction. These compressors supply air at 100 lb. pressure to the factory process, such as air hammers, paint sprays, etc.

The air is drawn into the air compressors through an air filter and discharges from the air compressors through after-coolers into two large air storage tanks just outside the compressor room. The cooling water for the compressors and the after-coolers is supplied under pressure with a closed system using Cyclo indicators rather than open funnel, this water being discharged to the water tank and used over again instead of being discharged to the sewer and wasted as is usually the case.

Complete equipment of all the necessary instruments for determining the performance of this plant is provided. Each boiler has its complement of draft gages, boiler steam flow meter and pressure gages. Hand controls for pulverized coal and sawdust burning equipment and fans are centralized at the front of each boiler burning these fuels. In the chief engineer's office, recording pressure and draft gages, steam flow meters, thermometers and electrical instruments give full records of operation. In addition, a gage board in the office carries a steam flow indicator and recorder for each department of the factory, showing the amount of steam supplied to each outgoing line. A switchboard on the gallery just outside the chief engineer's office controls the power through the various power house circuits.

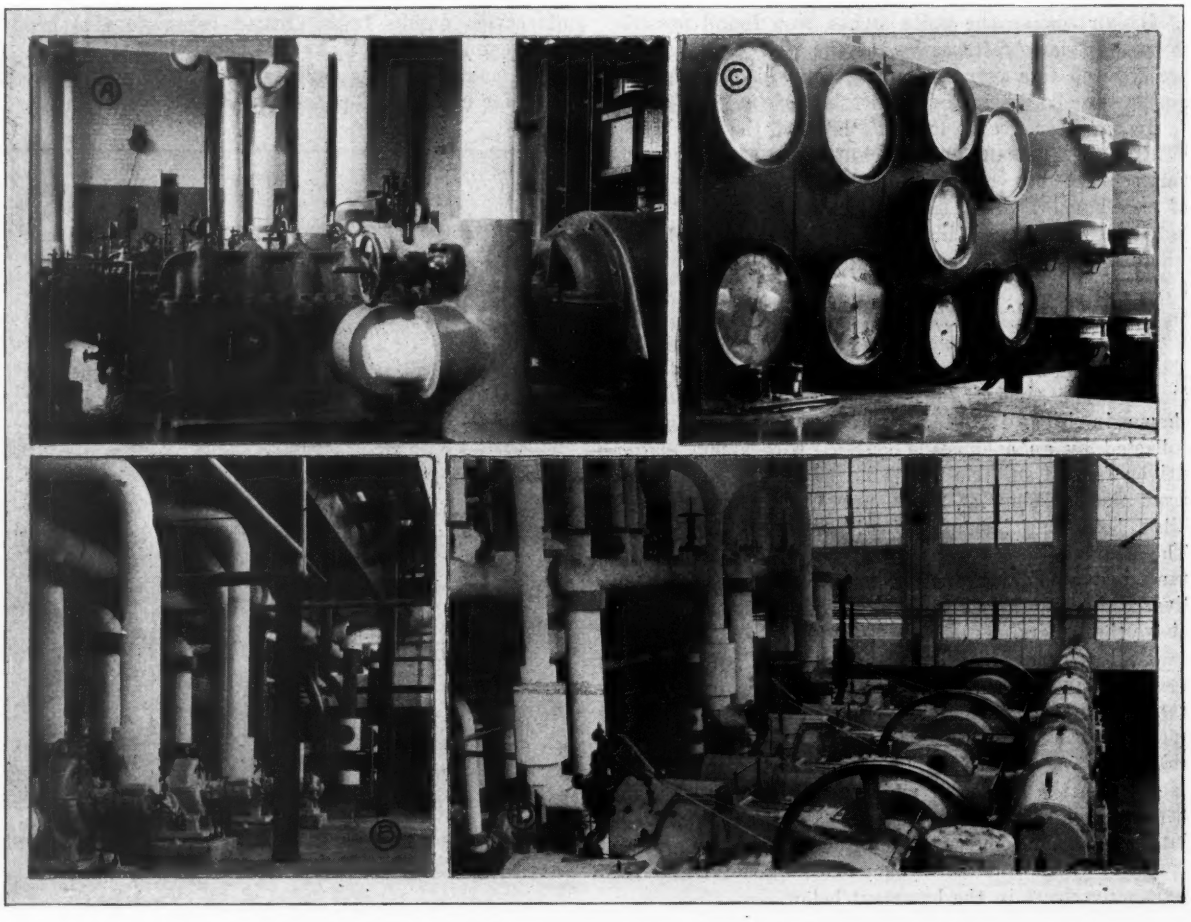


FIG. 6. (A) THREE BOILER FEED PUMPS, TWO TURBINE-DRIVEN AND ONE MOTOR-DRIVEN, ARE SET IN THE BOILER ROOM. (B) HOT WATER CIRCULATING PUMPS, SERVICE PUMPS AND FIRE PUMPS IN THE COMPRESSOR ROOM. (C) RECORDERS AND INDICATORS IN THE CHIEF ENGINEER'S OFFICE. (D) THREE STEAM ENGINE DRIVEN COMPRESSORS FURNISH AIR AT 100 LB. TO FACTORY. MOTOR-DRIVEN ANGLE-COMPOUND COMPRESSOR IS ALSO INSTALLED

Performance Data

Design and construction of the new plant at Flint. Unit No. 1 were carried out by the engineering department of the Fisher Body Corp.

Data covering operation of the new boiler plant for one month are shown in the following tabulation:

Month of July, 1927

Steam generated from coal	26,256,000 lb.
Coal burned	2,419,280 lb.
Actual evaporation, lb. water per lb. coal	10.8 lb.
Steam pressure gage	200 lb.
Feed water temperature	205 deg. F.
Factor of evaporation	1.03
Equivalent evaporation	11.124
Coal, B.t.u. per lb	14,400
Efficiency	75.19 per cent

(Note: Coal burned on stokers only.)

Steam generated from waste wood	14,418,000 lb.

Production of electric power by public utility power plants in the United States for August, September and October, 1927, as recently reported by the Geological Survey, Department of Interior, reached a total in October of 6,904,262,000 kw-hr., an increase of 5 per cent over the output for October, 1926. Of this amount 4,528,735,000 kw-hr. were produced by fuels and 2,375,927,000 kw-hr. by water power.

Ventilation of Trenton Channel Power Plant

JETS OF HEATED AIR SWEEP ALONG UNDER SIDE OF TURBINE ROOM ROOF AND INSIDE OF WINDOWS TO PREVENT CONDENSATION, WHILE CIRCUIT OF AIR IS CONTROLLED THROUGHOUT BUILDING. BY JAMES N. LIVERMORE*

IN THE DESIGN of The Detroit Edison Co.'s Trenton Channel Power Plant, experience with previous plants made clear the necessity of careful study of and adequate provision for ventilation in all parts of the station.

To maintain correct atmospheric conditions, summer and winter, in the turbine rooms of the older stations proved a considerable problem. Here the air had a tendency toward a high relative humidity, which was due largely to steam leakage from governors, valves, glands on high pressure ends of turbines and auxiliaries. Air washers were another factor contributing moisture. These were used to clean and, incidentally, cool the air supplied to the turbo-alternators. During the winter the nearly saturated air in the turbine room struck the cold surfaces of the windows and the under side of the roof where it was chilled to the dew point. This caused the surfaces to be covered with free moisture and the resulting drip was of sufficient amount to endanger the electrical equipment below, as well as create a decided nuisance.

To overcome this difficulty, several schemes were tried in the older plants. A monitor along the ridge of a turbine room roof was installed, providing a natural vent for the warm, moisture laden air. The result was, however, that the moment the interior atmosphere came in contact with the cold surfaces of the monitor, serious condensation took place. Double sash was used in the windows to prevent fogging, but the results were not satisfactory. Insulating the roof to effect a great enough temperature difference between indoor and outdoor surfaces was tried at one of the plants with only partial success. To install sufficient insulation on a roof as large as the one contemplated, however, was not believed practical.

Observations and studies following these installations led to the conclusion that the simplest method of ending trouble from condensation was to change the *condition* of the air, rather than to attempt to dispose of it without change.

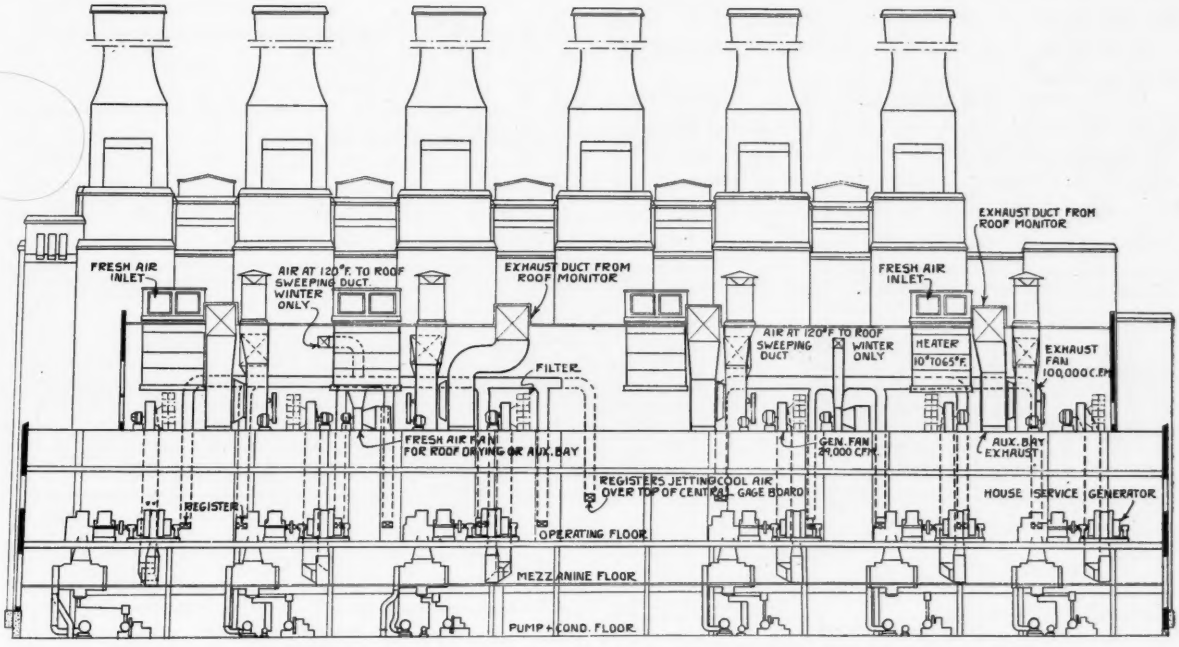

FRESH AIR INLET
AIR AT 120°F. TO ROOF SWEEPING DUCT. WINTER ONLY
EXHAUST DUCT FROM ROOF MONITOR
FILTER
FRESH AIR FAN FOR ROOF DRYING OR AUX. BAY
REGISTERS JETTING COOL AIR OVER TOP OF CENTRAL GAGE BOARD
REGISTER
OPERATING FLOOR
MEZZANINE FLOOR
PUMP & COND. FLOOR
FRESH AIR INLET
EXHAUST DUCT FROM ROOF MONITOR
AIR AT 120°F. TO ROOF SWEEPING DUCT
WINTER ONLY
HEATER 10*1065°F.
EXHAUST FAN 100,000 C.F.M.
GEN. FAN 24,000 CFM
AUX. BAY EXHAUST
HOUSE SERVICE GENERATOR

FIG. 1. SECTION THROUGH AUXILIARY BAY AND FAN ROOM LOOKING TOWARD BOILER HOUSE

GENERATOR COOLING SYSTEM HAS LITTLE EFFECT ON TURBINE ROOM AIR

Trenton Channel turbine room is designed to house six main units, each of 50,000 kw. capacity, six d.c. house service units, each of 4000 kw. capacity, and three a.c. house service units, each of 2000 kw. capacity. Main units adaptable to a closed system of cooling were chosen; i.e., each alternator is so equipped that air is recirculated by means of blading on the rotor, first through the alternator, then through a fin tube air cooler, then back through the alternator and so on. (The air cooler is connected so that the heat removed from the air may be absorbed either by condensate or by condenser circulating water. The latter has been used almost continuously except in very cold weather.)

*Engineering Department, Detroit Edison Co.

By this arrangement the cooling system of each main generator is isolated and has little or no effect on the condition of the turbine room air.

Heated Air Sweeps Roof and Window Surfaces

Another step in reducing sweating troubles was the provision for discharging large quantities of heated fresh air into the turbine room at effective points. As shown on Figs. 1 and 2, in rooms on either side of the turbine house proper are located fans and heaters. These heating sets take their air from out-of-doors and supply it to each of two long ducts which run the full length of the turbine room along the low sides of the sloping roof. The ducts are fitted with an adjustable slot close to the roof through which air jets in a thin sheet toward the monitor at the ridge. The roof steel has been so arranged that this stream of air can flow along the under side of the roof slab without interruption. The monitor serves to house an exhaust duct which also runs the full length of the roof and to which are connected four large exhaust fans. The combined capacity of the exhaust fans is considerably in excess of the combined capacity of the supply fans, which makes it possible to draw in fresh air through leaks in the building structure when desired.

In the north and south ends of the turbine room there is a very large window area and also a considerable amount on the west side. These have been taken care of in a manner similar to that followed on the roof. At the bottom of each large window sash is located an air box with an adjustable slot which jets heated air over the window. The heated air for this purpose is supplied by an independent heater set at either end of the building. In the design of all this interior duct work much care was taken to prevent mutilating the appearance of the turbine room, either by concealing the ducts in the walls, or locating them as inconspicuously as possible.

Drying of the turbine room air is further accomplished by two other agencies, one being a complete installation of radiators about the walls. The steam supply for this direct radiation, and also for all heater coils, is obtained by bleeding the lower stages of the auxiliary turbines. The other agency is the heated air discharged from the house service generators.

Ventilating Equipment Centralized in Gallery

House service units in the auxiliary bay require a definite amount of cooling air, and it was also foreseen that unless adequate ventilation was provided in the locality surrounding them, the temperatures here in summer would be exceedingly uncomfortable to the operating force. The logical location for the equipment necessary to take care of this was on the floor directly above the auxiliary bay. Consequently, this gallery was enclosed the full length of the turbine house and used to contain the major part of all ventilating equipment. This fan room, as shown in Fig. 1, is supplied with air drawn in from out-of-doors through a heater, which, in cold weather, brings the temperature up to 65 deg. F. Six of the fans drawing this air in discharge directly through ducts to each of the six 4000-kw. generators below. Air filters are at present being installed on the inlets of these fans to prevent the accumulation of dirt on the generator windings. Two other fans taking their air from the same space are connected to heaters which, in winter, raise the temperature to 120 deg. for roof sweeping purposes. For the comfort of the operating force in warm weather these same fans are used without the heaters and discharge air at outdoor temperature at various low points along the wall in the auxiliary bay.

In Figs. 3 and 4, it may be noted that the exhaust fans have a forked discharge so equipped with louvre

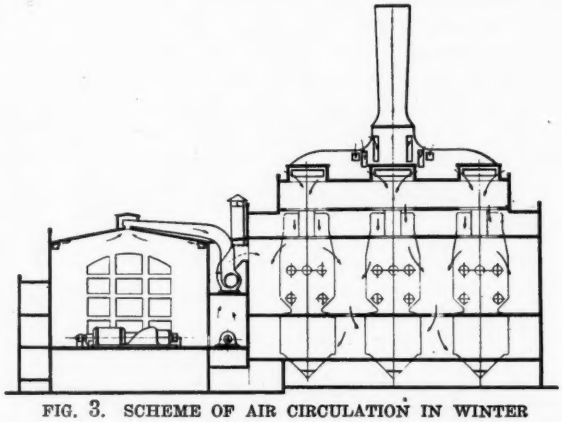


FIG. 3. SCHEME OF AIR CIRCULATION IN WINTER

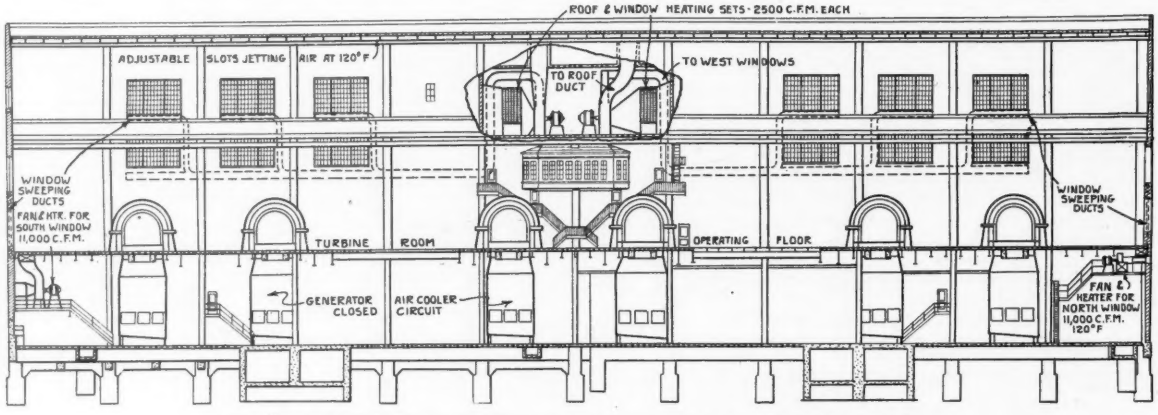

ROOF & WINDOW HEATING SETS - 2500 C.F.M. EACH
ADJUSTABLE SLOTS JETTING AIR AT 120° F
TO ROOF DUCT
TO WEST WINDOWS
WINDOW SWEEPING DUCTS
FAN & HTR. FOR SOUTH WINDOW 11,000 C.F.M.
TURBINE ROOM
OPERATING FLOOR
WINDOW SWEEPING DUCTS
GENERATOR CLOSED
AIR COOLER CIRCUIT
FAN & HEATER FOR NORTH WINDOW 11,000 C.F.M. 120°F

FIG. 2. LONGITUDINAL SECTION THROUGH TURBINE ROOM LOOKING WEST

dampers that the exhausted air may be released either to the outdoors or to the upper part of the boiler house, where it may effect a small thermal saving and will furnish a part of the combustion air.

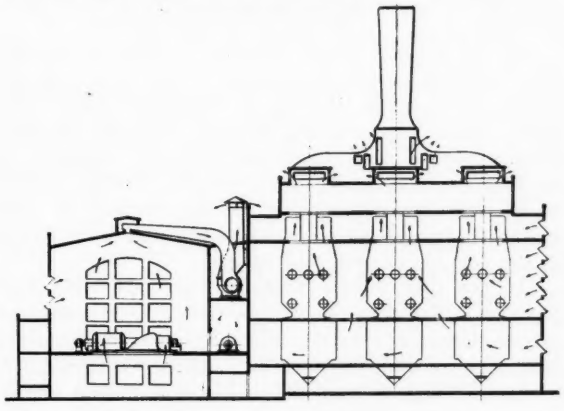


FIG. 4. SCHEME OF AIR CIRCULATION IN SUMMER

In these figures is also shown a schematic outline of air circulation in the boiler house and turbine room for summer and winter operating conditions. It will be noted that in summer the combustion air in the boiler house is drawn in through windows in the outer walls. At the top of the boiler house the warm indoor air flows by gravity out the open windows of the monitors and also up through the breechings around the boiler uptakes. In winter the boiler house windows and monitors are kept closed and combustion air is drawn in through the housings around the uptakes. This, combined with the air supplied by the turbine room exhaust fans, is drawn down through large openings in the boiler house floors to the furnace air intakes.

The preceding description covers the most extensive ventilating system at Trenton. Provisions for ventilation in other parts of the station, however, might be briefly mentioned.

Ventilation of Preparation and Switch Houses

In the coal preparation house where all the fuel consumed is pulverized, many precautions have been taken on account of coal dust. Among other things, it was found desirable to use motors all of the fully enclosed self ventilated type; this in turn involved a large duct system supplying outdoor air to each motor. Each motor was guaranteed to pull the necessary amount of air to cool itself against ½ in. static pressure, so that a supply fan was not required.

In one large room containing house service switching equipment, emergency exhaust fans of the propeller type were installed. The purpose of these was to provide a means of quickly removing the smoke from the room in case of electrical breakdown, thereby permitting inspection and repairs at the earliest possible moment.

At first glance, the reader may judge the ventilating equipment throughout the station far too elaborate to be justified, but, as explained at the outset, these things have been mainly the outgrowth of our own experience. Wherever we have been able to preclude trouble due to inadequate ventilation, it has proved an exceedingly good investment; conversely, adding ventilating equipment to stations not originally intended for it has proved expensive business.

Increasing Superheat in Existing Boiler Units

Addition of Radiant Superheaters, Changes in Baffles, Use of Steam Purifiers, Changes in Tubes Under Superheaters and Other Factors Influence the Superheat

SUBSTANTIAL GAINS have been made in the economy of a number of plants by increasing the existing superheat. This has been accomplished by covering the steam circulating tubes, installing radiant heat superheaters, changing the boiler baffling, increasing the superheating surface, installing steam purifiers, using ferrules for improving steam distribution in the superheaters and removing boiler tubes below the superheater. Considerable data have been collected on this subject by the N. E. L. A. and published as part of a serial report.

At the Northeast Station the superheat from 13,500-sq. ft. cross drum boiler units has been increased by covering the steam circulating tubes directly above the superheater with tile. Tests conducted before and after with conditions as nearly alike as possible show an increase in superheat from 147 to 186 deg. at 160 per cent rating, while at 240 per cent rating the superheat increased 215 deg. F. Superheat was also increased in similar units as shown in Fig. 1 by installing 88 sq. ft. of radiant heat superheater surface in the side walls of similar units. The steam circulation is from boiler drums through the radiant heat superheater to the convection superheater. This circuit was used as it simplified pipe connections.

At the Ashley St. Station, 5580-sq. ft. boilers

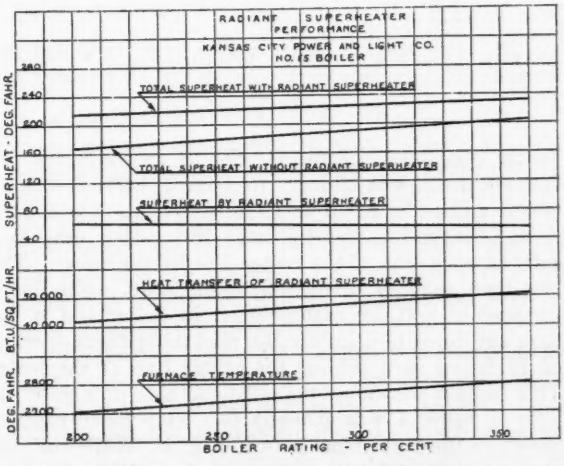


FIG. 1. SUPERHEAT AS EFFECTED BY ADDING RADIANT HEAT SUPERHEATER IN NORTHEAST STATION

originally equipped with 736 sq. ft. of convection superheaters located at the back of the first pass, gave a superheat of 150 deg. F. with stoker firing, but when the boilers were converted to pulverized coal with water cooled side walls the superheat was reduced nearly 100 deg. F. This condition was remedied by placing forged steel radiant heat superheaters in the rear wall.

Results of experiments conducted on a 19,650-sq. ft. boiler at the Hudson Ave. Station are shown in Fig. 2. This boiler as baffled is shown in Fig. 3. In Case 1, baffle A was 24 in. deep and extended the full furnace

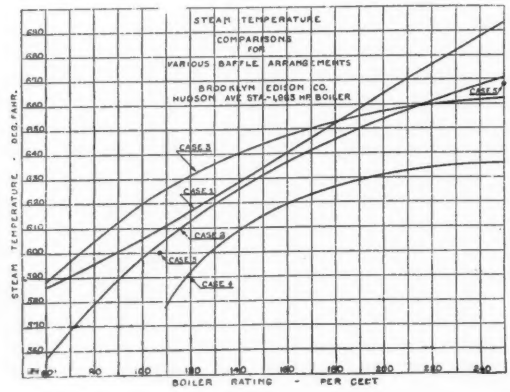


FIG. 2. EFFECT OF BAFFLE CHANGES ON STEAM TEMPERATURE AT HUDSON AVE. STATION

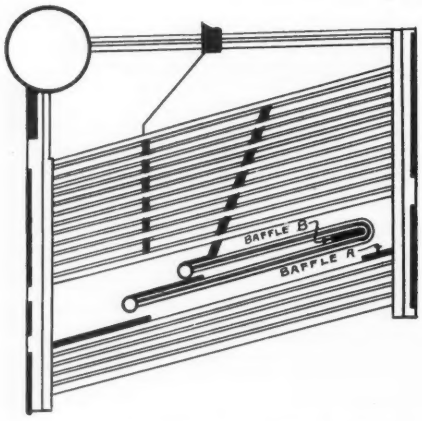


FIG. 3. THIS BAFFLE ARRANGEMENT WAS USED FOR THE SUPERHEATER EXPERIMENTS CARRIED ON AT HUDSON AVE. STATION

width. In Case 2, baffle B, also 24 in. deep the full furnace width was added. In Case 3, baffle B was removed and baffle A cut to 18 in. deep. In case 4, baffle A was changed to step up baffle 18 in. deep, extending 4 ft. on each side of the center line of the boiler. This was then reduced to the width of 12 in. extending a distance of 8 ft. on each side of the boiler and it was then cut down to 6 in. for the remaining furnace width of 12 ft. on each side of the center line of the boiler. This baffle is shown on the left-hand side of Fig. 4. In Case 5, baffle A was changed to a step down baffle as shown in the right hand side of Fig. 4. While the tests were not extended so that the desired results were conclusively determined, the information obtained should permit designing the next baffle on a most scientific basis and produce a nearer approach to the desired steam temperature characteristics.

Results Obtained Depend Upon Type and Make of Boiler

At the Brunot Island Station, ten 8220 sq. ft. Stirling boilers each containing 341 sq. ft. of superheater surface gave about 100 deg. F. superheat when stoker fired. When changed to pulverized fuel the superheat dropped to from 25 to 40 deg. F. To improve this condition a new superheater having a surface of 1181 sq. ft. was installed, raising the superheat from about 40 to 120 deg. at 200 per cent rating and from 25 deg. to 150 deg. at 300 per cent rating.

In the East Peoria Station experience with steam purifiers differed in the various boilers. Averaged and extended results over a period of time showed no gain in superheat when installed on Connelly boilers, an increase of 2 deg. on Badenhausen boilers and an increase

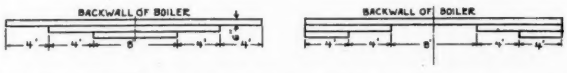


FIG. 4. DESIGN OF STEP UP AND STEP DOWN BAFFLE A AS USED IN CASE 4 AND 5

of 21 deg. on B. & W. boilers. All of these boilers were rated at approximately 500 hp., the boiler rating varying from 150 to 175 per cent.

At the same plant the removal of 20 tubes from the tube banks below the superheater did not raise the superheat appreciably. Experiments demonstrated that the portion of the superheater in the center of the boiler was doing most of the work.

By installing a baffle over the boiler tubes directly under the hottest portion of the superheater the gases were distributed better resulting in an average superheat approximately 23 deg. higher than that obtained without the baffle installed.

On one of the other boilers a short baffle was installed directly over the superheater in the center of the vertical pass. This resulted in an increase of approximately 20 deg. F. in superheat without the removal of any of the boiler tubes below the superheater. This again would indicate that the removal of boiler tubes below the superheater does not increase the superheat appreciably. On the other hand, it does shorten the life of the hanger rods and beams supporting the superheater.

At the new Klingenburg electric power station which has lately been put in operation in Berlin, Germany, by the Berlin Municipal Electricity Co., an initial generator capacity of over 300,000 kv.a. is installed. Steam is generated by a battery of 16 boilers each having a heating surface of 18,837 sq. ft. Boilers are all fired by pulverized fuel and operate at a pressure of 35 atmospheres or about 514.5 lb. per sq. in. and at a temperature of 425 deg. C. or 800 deg. F. To save time, the 16 boilers were constructed by eight different German concerns, who had to conform in every detail to the specification drawn by the main contractors, the Allgemeine Elektricitäts Gesellschaft of Berlin.

Steam Generators at Morgan & Wright Plant

INTERESTING DESIGN FEATURES, FLEXIBILITY, HIGH EVAPORATION AND HIGH HEAT LIBERATION AND COMPACTNESS ARE CHARACTERISTICS OF TWO 100,000-LB. PER HR. STEAM GENERATING UNITS INSTALLED BY INDUSTRIAL PLANT IN DETROIT. BY GARRETT BURGESS*

AT THE Morgan & Wright plant of the United States Rubber Co., Detroit, Mich., are installed two Combustion Steam Generating Units. The first of these units went on the line in March, 1927. Figures 1 and 2 show the general arrangement and emphasize the compact design which was necessary to adapt so small an available space to a large steaming capacity.

The features incorporated in the steam generators are as follows: (a) full water-cooled combustion-chamber walls integral with the circulatory system of the generator, (b) practical elimination of brickwork in the furnace, (c) water-screen, (d) tangential firing. These features will be briefly discussed.

FEATURES OF THE STEAM GENERATORS

(a) The roof and four side walls of the combustion chamber are of the finned-tube type; the tubes are 4 in. in diameter placed on 7-in. centers. The tubes are backed up by light tile sections laid up dry, behind which is 1½ in. of rock-wool insulation and an outside metal casing. This type of construction serves a four-fold purpose:

(1) It provides effective and efficiently disposed steam generating surface. The fin tubes comprising the walls of the combustion chamber are exposed to direct furnace temperature and absorb by radiation a large proportion of the heat liberated.

(2) It reduces combustion-chamber temperature, thus permitting operation with less excess air and higher rates of heat liberation without the formation of slag and damage to furnace walls.

(3) It reduces heat losses through the walls as well as absorption and retention of heat by the walls.

(4) It reduces floor space required per unit of steaming capacity by reducing wall thickness. The walls are less than 6 in. thick yet, even at the highest ratings, they remain at a temperature such that the hand can be held against the wall without discomfort.

(b) Elimination of brickwork reduces to practically nothing the usually large item of refractory maintenance. Furthermore, the furnace temperature can be brought up quickly without danger of spalling and serious expansion strains. As a consequence, boiler outage is diminished and the availability for quick steaming tremendously increased. On several occasions the steam generators have been lighted and brought on the line from a cold condition in from 12 to 15 min. without damage.

METHOD OF DISPOSING OF ASH

(c) In furnace operation at high rates of heat liberation, high combustion-chamber temperatures are attained. At maximum ratings, these steam generating units are designed for a liberation of over 34,000 B.t.u. per cu. ft. of furnace volume. The high temperatures resulting are far in excess of the fusing point of the ash contained in the coal and provision must be made to prevent the molten ash particles from fusing together in a solid agglomerate mass as they fall into the hopper below the combustion-chamber. The use of a water-screen serves this purpose. Figure 1 shows the screen located below the combustion-chamber. This screen consists of six rows of three-inch plain tubes. As the gases pass downward through the screen, the fused ash particles are chilled below their solidification temperature and fall into the hoppers in a granular state. Such material is readily removed by means of the screw conveyor shown in the illustration.

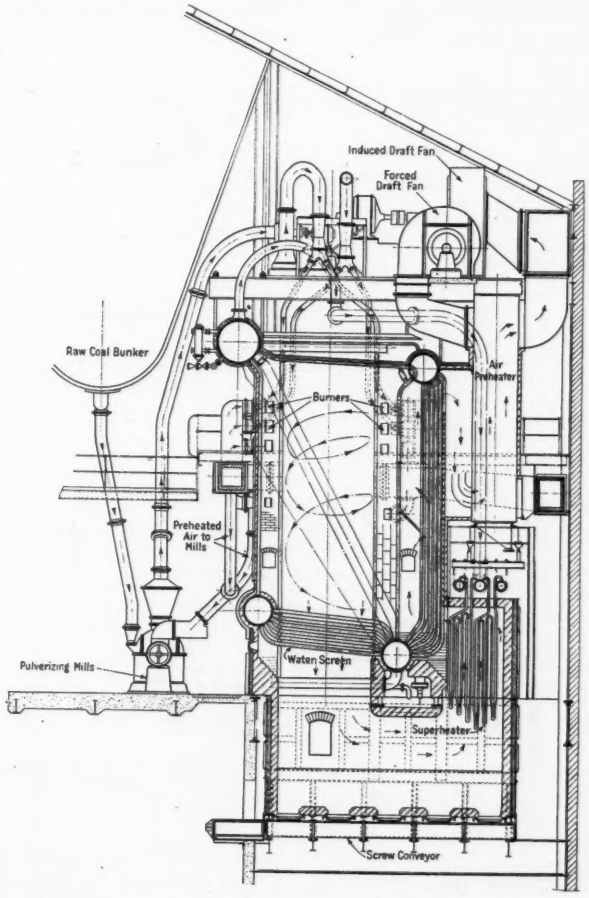


FIG. 1. CROSS-SECTION THROUGH STEAM GENERATOR

(d) Coal in pulverized form is introduced through eight burner nozzles located in the four corners near the top of the combustion-chamber, as in Figs. 1 and 2. The burners are so pointed that the incoming streams of coal and air lie tangent to an imaginary circle, with the result that rapid rotation of the furnace gases takes

*Chief Engineer, Morgan & Wright plant of U. S. Rubber Co., Detroit, Mich.

place. Air coming in around the burners is quickly cut by the rotating gases and intimate mixture takes place before segregation can occur.

The Steam Generator, apart from the fuel burning system, consists not only of steam surfaces, drums, water-screen, and circulatory connections, but also of superheater, air preheater, ducts and draft fans, all designed to accord with the specific requirements and designed as a unit. Included also are such essentials as soot-blowers, ash-removal-equipment, steam piping and boiler trimmings.

These Steam Generating Units are each rated at 100,000 lb. per hr. evaporation from and at 212 deg., but guaranteed to deliver 120,000 lb. as a maximum maintained rating. With feedwater at 210 deg. F., a drum

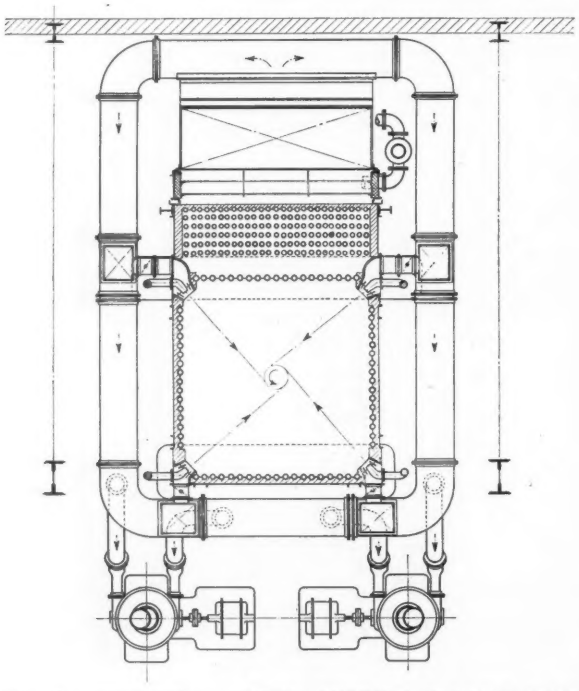


FIG. 2. HORIZONTAL SECTION SHOWING FURNACE WALL AND TURBULENT ACTION OF BURNERS

pressure of 205 lb. and a total steam temperature of 550 deg., these figures correspond to actual outputs of 87,500 lb. and 104,350 lb., respectively. Performance records for a 10-day period are shown in the accompanying table.

On Nov. 8, the day showing highest evaporation, the heat liberation was equivalent to 31,500 B.t.u. per cu. ft. of furnace volume per hour.

General Construction of Units and Accessories

Figures 1 and 2 show the arrangement of drums and headers. All pressure parts are supported from above by means of four U-bolts, to provide for complete freedom for expansion and permit temperature to be quickly raised.

Referring to Fig. 1, the path of gas travel is as follows: Downward in a helical path through the combustion chamber; through the water screen; through the superheater and up through the tubes of the convection bank; thence through the air preheater to the induced draft fan and stack. Air for combustion enters the forced draft fan, passes downward through the air-preheater and into the duct which encircles the generator. From here it enters the ports around the burners. Air is also withdrawn from this duct to supply the pulverizing mills.

The superheater is of the vertical type and is proportioned to deliver steam at 550 deg. at maximum rating. This corresponds to a superheat of 160 deg.

The air-preheater is designed to deliver air to the duct at 636 deg. The heat transfer surface of the air preheater consists of sheet iron elements similar to envelopes arranged next to each other and separated by spacer bars. The hot flue gases pass between the elements and the air through them. The elements are four feet wide and 20 ft. long, housed in an insulated steel casing supported from the building columns.

Draft-fans are operated by slip-ring induction motors with controls proportioned to give a variation from half-speed to full-speed. Dampers are provided which may be operated electrically from the main floor.

TABLE SHOWING DAILY PERFORMANCE OF STEAM GENERATOR FOR 10 TYPICAL DAYS

DATE	Evaporation 1000 lb. Actual	Equiv.	Coal Burned	BTU Coal as fired	Efficiency as fired basis
11/1/27	1447	1694	145,600	12,810	88.1
11/2/27	1429	1671	142,400	12,890	88.4
11/3/27	1299	1520	130,000	12,940	87.6
11/4/27	1369	1602	140,000	12,770	86.8
11/5/27)					
11/6/27)	Week-end.	Boiler off line.			
11/7/27	1460	1708	148,400	12,860	86.8
11/8/27	1526	1785	150,000	12,920	89.3
11/9/27	1446	1692	142,800	12,830	89.3
11/10/27	1346	1575	136,000	12,870	87.5

Daily hours on line: 16.

The steam generator is equipped with two independent coal systems, consisting of feeder and mill, exhauster, distributor, burner piping, and burners. When operating on a single mill, 60 per cent of the full load rating of the generator may be attained. This design provides considerable flexibility as repairs and replacements may be made during operation.

Crushed coal is stored in a suspension bunker and delivered to the feeders, which are integral with the mills, through a weigh-scale which automatically records the weight consumed.

From the mills, the coal is picked up by the exhausters located above the unit and passed through distributors to the burners. The mills are equipped with fineness regulators which make possible the control of the degree of pulverization and assure uniform fineness.

Control Equipment Is Complete and Easily Handled

A complete electrical interlock insures proper sequence of operation in starting and safeguards the equipment in case of enforced shutdown. Control is from a glass enclosed room located between the two generators. From this point of vantage, a single operator is in a position to know at all times the conditions obtaining and to make such changes and adjustments as may be required.

On the control board have been installed all the latest types of indicating and recording instruments necessary to give the operator complete knowledge of the conditions existing; namely, indicating and integrating electrically operated feedwater flow meter; indicat-

ing, integrating and recording electrically operated steam flow meter; recording and indicating steam pressure gages; indicating ammeters showing load on each pulverizer, exhauster and fan unit; multi-pointer draft gage; electrically operated CO_2 recorder; electrically operated multi-point pyrometer recording gas temperature entering and leaving air preheater, preheated air temperature and total steam temperature; and a two-pen recording temperature gage, showing temperature of coal leaving pulverizers.

In addition to these instruments, the board is equipped with suitable mechanisms for manual operation of the units, as they are not as yet equipped for automatic control. If found desirable, automatic control will be provided at a later date.

Push button stations, with indicating lights, are provided for starting and stopping of motor units and for operating main dampers on the forced and induced draft fans; mechanical devices permit adjustment of coal feed to pulverizers and auxiliary air for tempering primary preheated air to pulverizers. These complete the controlling apparatus.

Despite the apparent complexity of the unit itself, together with the controlling apparatus, operation of the unit is surprisingly simple. A single operator, with a thorough knowledge of the unit under his control, finds that it can be brought on the line quickly and, when once on the line, that it is exceedingly responsive to adjustments. Bringing the unit on the line from "cold" requires the following operations:

Fans are started and dampers adjusted to hold approximately 0.3 in. induced draft, and zero pressure on forced draft in the furnace. Pilot lights on one set of burner nozzles are lit (artificial gas direct from city mains is utilized for this purpose). One pulverizer unit is now started with auxiliary dampers closed and no air circulating through pulverizer. Coal feed is increased until mill is loaded to approximately 60 amp. (These mills are of three and one-half ton per hour capacity, each driven by a 75-hp. induction motor.) Air supply is gradually increased with coal feed until on line.

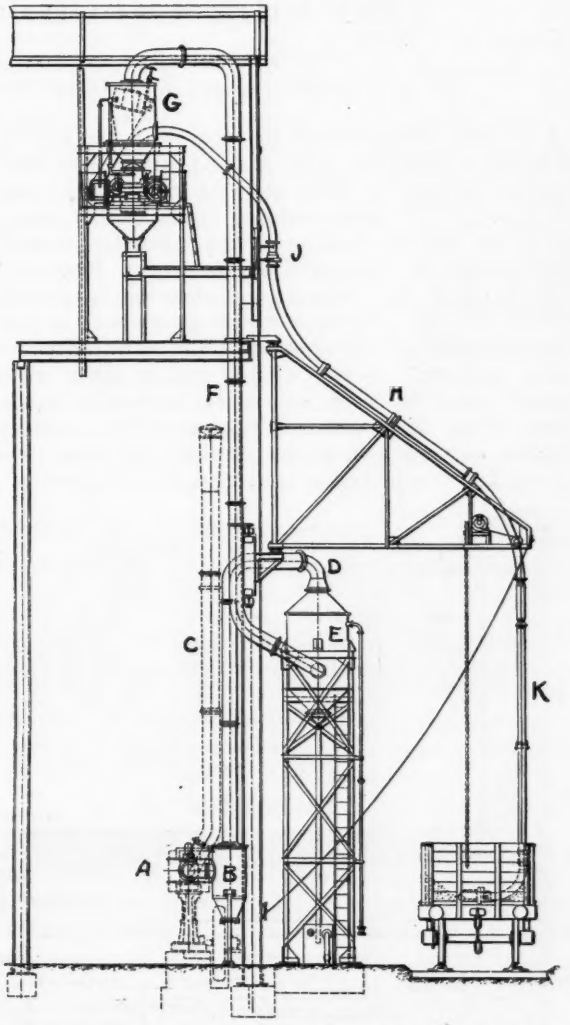
The time interval between "starting" and "on line" is usually between 30 and 40 min., although in case of necessity, this interval may be cut to less than half.

Pneumatic Coal Handling

Freedom from Dust and Labor Saving Offset First Cost

SPITE OF the greater power required for handling coal—not ashes—by a pneumatic system, than for mechanical conveyors, advantages in flexibility, freedom from dust, convenience of installation and sometimes saving of labor have resulted in adoption of this method to some extent. Recently a plant of 10 t. an hour capacity was installed at the Carrow works of J. & J. Colman, Ltd., Norwich, Eng., details of which are given in Engineering of London. The conveyor plant is for raising coal from cars to the overhead bunkers in the boiler house, location of the plant being such that spreading of coal dust could not be allowed. Possibility of operation by one man was also a factor in the decision to use this system.

General arrangement is shown in the sectional view. Suction is produced by a pump A which draws air from receiver B and discharges through pipe C to atmosphere. Inlet to the receiver is from the top of filter tank E through pipe D, this filter serving to remove dust from the air by means of a coke bed in its upper portion and water sprays in the lower portion. Air comes into the side of filter E through pipe F from the top of discharge chamber G, which has inside a cyclone head for separating all except the finest coal dust from the carrying air.



COAL IS RAISED BY SUCTION AND DISCHARGED TO OVERHEAD BUNKERS

Coal is lifted by suction air from the car through riser J H K and delivered into the side of the discharge head through the down-turned end of the pipe. Section H is carried on a jib which swings to meet the car position, or folds against the building when not in use, motion being allowed by swing joint J. Section K can be telescoped by means of the chain hoist near the end of the jib and has at the bottom a flexible section with inlet nozzle of steel plate, which can be moved about by hand and has a valve to control inlet air so as to

prevent choking and confine the coal to the central portion of the pipe to prevent wear.

To deliver coal from the discharge head to the scraper conveyor below, a tipper seal gate is provided having two compartments divided by a center partition. The upper surface is cylindrical, fitting a cylindrical seat so as to form a packed air seal. It rocks so that as one compartment fills, the other empties, reversal being automatic and springs being provided in the actuating mechanism to avoid damage in case coal is jammed in the filling opening. Outlet from the compartments is through a swing door which falls shut when a compartment is in filling position. Air ports are provided to break vacuum as the compartment comes to emptying position, so that the door opens by gravity, and to exhaust air from a pocket before it opens to the discharge head to avoid an uprush of coal dust.

Checking Up on the Heating System

DETAILS OF RADIATORS AND UNIT HEATERS THAT MAY ASSIST THE INDUSTRIAL PLANT ENGINEER IN OVERCOMING AND FORESTALLING TROUBLE

AT THIS SEASON of the year with the heating period about half over, the industrial plant engineer should have a fairly accurate knowledge of any weak points that have developed in his heating system since the last overhauling period. Regular summer overhauling is imperative, as has been frequently pointed out in these columns and when this is properly carried out, little trouble should be encountered in running through the heating season. The industrial power plant engineer, however, will do well to make out a regular schedule of inspections of his heating equipment during the season, making some of the necessary repairs at once and noting carefully the ones that should be made after the equipment is shut down.

It is assumed that piping, valves, traps and the like have been overhauled during the summer, but if anything does go wrong with any of this equipment, while it is in operation, it should be repaired as soon as possible. Losses due to leaks of steam and water are large enough in most cases, as every engineer knows, to counter-balance the trouble and cost of stopping them immediately. Radiator valve packing that is not tight or air valves that do not function are constant sources of such loss and cause much annoyance.

Dirt causes many of the troubles with such equipment, especially in vapor or vacuum heating systems. Thermostatic traps should have been thoroughly cleaned during the summer overhauling, by removing the ther-

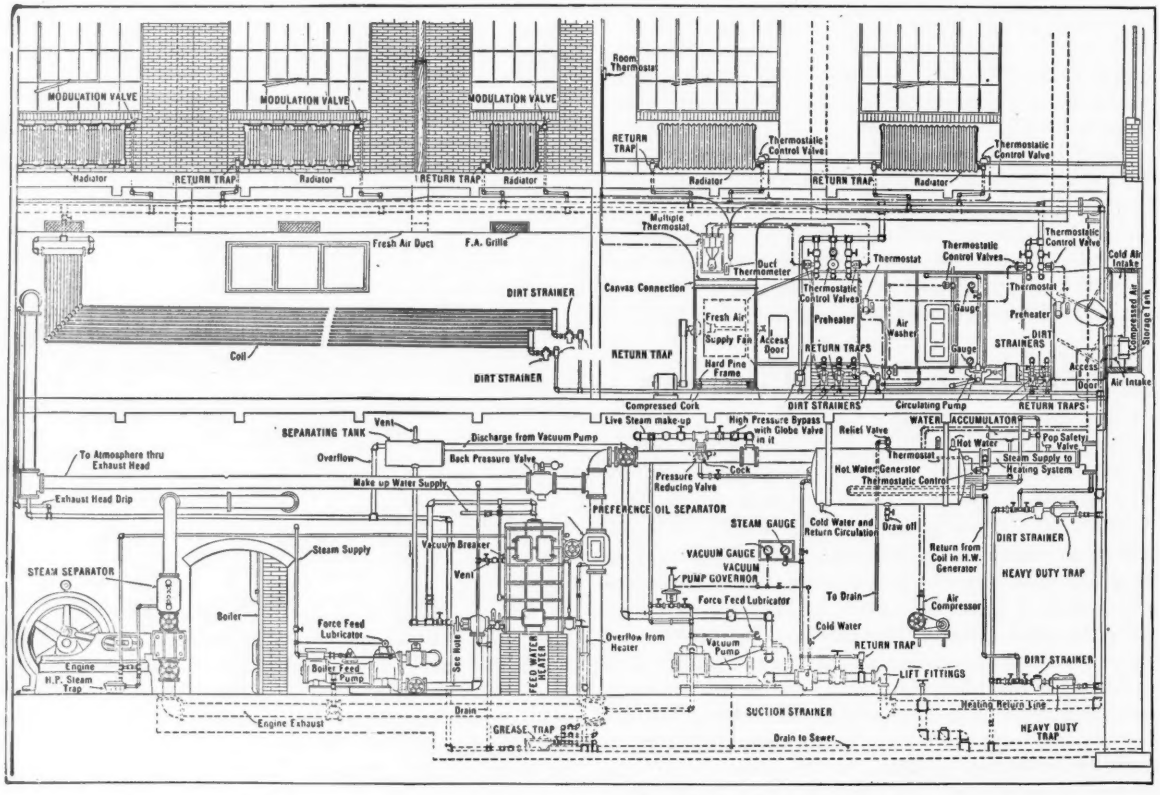


FIG. 1. VACUUM HEATING SYSTEM USING ENGINE AND PUMP EXHAUST; THIS IS TYPICAL OF MANY INDUSTRIAL PLANT LAYOUTS

mostatic elements and wiping them with a cloth dipped in gasoline. While cleanliness of traps, valves and the like seems a trivial point, it really is not; it is surprising that many engineers fail to appreciate its importance. Seats of supply valves and packing of return traps should be looked at occasionally. Needless to say, a regular inspection schedule is best for supervising such items.

Removal of condensate and air from heating surfaces by traps should be an entirely automatic operation. Most traps are properly adjusted at the factory and, if kept clean, should function in this automatic way right through the season. Expansion joints, too, should need little attention.

Insulation of steam mains and piping, if properly installed at first, gives no trouble. If a leak appears, however, it may soak the insulation, impairing its insulating properties. It is only in such cases that repairs are needed as a rule. Pipe tunnels and underground lines may well follow the best practice of district heating systems to secure reliability and convenience of operation.

One of the most important things to watch in the heating system is the layout of piping and equipment according to the designs made by the manufacturer. Such layouts differ in many of the smaller details and if the system has been extended during the summer or if any additions are found necessary after starting up, they should follow closely the manufacturer's or designer's diagrams so that satisfactory results will be obtained with the particular equipment used.

Details of drips of steam mains and risers also warrant attention. Several of these, for one particular type of trap, are shown in Figs. 2 and 3.

Heat Transmission in Buildings

In industrial plants when complaints are received of insufficient heat in certain rooms, or buildings, some interesting problems arise. Sometimes these can be solved by thermostatic control of the whole system, so that buildings or rooms that are receiving too much steam can be balanced with those not receiving enough. In many cases, by careful regulation of supply to individual buildings, it is possible materially to reduce the total steam consumption.

It is well to make sure that the heat transmission from heated rooms in adjoining colder ones does not increase the total steam consumption unduly. If the building has been properly constructed and the heating system properly designed, this will not occur. Nevertheless, this point should be considered by the industrial plant engineer when any complaint arises as to insufficient heat. Heat is lost from a building or room by

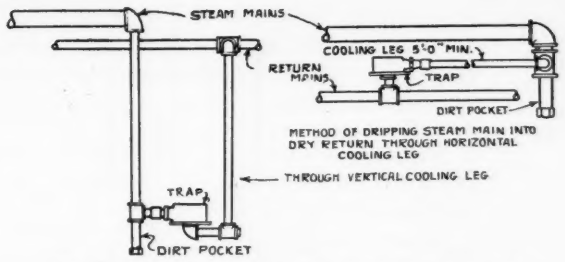


FIG. 3. END OF MAIN DRIPS INTO DRY RETURN

transmission through the various surfaces that separate it from spaces of lower temperature. In general outside wall and outside glass surfaces are the only ones seriously considered in computing the needed radiation for a building. If an unheated space occurs above a ceiling, below a floor, or on the other side of a partition, allowance must be made for it in designing the heating surface. This is not easy to predict, however, so the designer must make certain assumptions. After the building is in use, industrial demands may change the conditions and the engineer must meet these changes with proper changes in the heating systems.

Effects of winds or air movement, of enclosing radiators, of the position of the radiator, of moving belts, and of lights and persons are factors that may have to be taken into account sometimes. In most cases, several of these factors, such as the heat emitted by persons, should not be allowed to influence calculations of required radiation. Special care is needed where large audiences or large groups of people are involved. In industrial plants, of course, the concentration of human beings is seldom great enough to warrant consideration of this factor. In any case, the actual heating installation, exclusive of other heat sources, should always be enough to maintain at least 40 deg. F. in the building.

On the other hand, if lights or pieces of machinery emitting heat are always available during the working hours, some account may be taken of them. For electric lamps, the heat emitted is approximately:

B.t.u. per hr. = watts per lamp $\times$ number of lamps $\times$ 3.415.

Effect of moving machinery and belts in increasing heat transmission by circulating the air is appreciable; in some cases in which belted machinery has been changed to motor driven, relocation and enlargement of radiators have been necessary to give proper heating effects. Figure 4 shows the effect of humidity on heat transmission as given by John R. Allen.

Various types of enclosed radiating surface are on the market and the manufacturers of these furnish figures on their heat transmission characteristics. Many

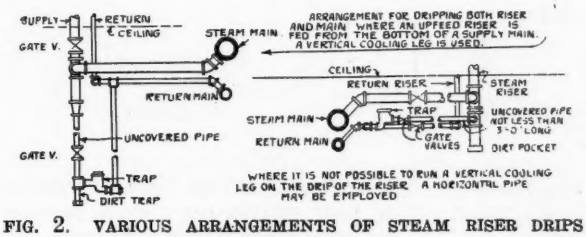

SUPPLY
RETURN
CEILING
GATE V.
STEAM MAIN
ARRANGEMENT FOR DRIPPING BOTH RISER AND MAIN WHERE AN UPFEED RISER IS FED FROM THE BOTTOM OF A SUPPLY MAIN. A VERTICAL COOLING LEG IS USED.
CEILING
RETURN RISER
STEAM RISER
RETURN MAIN
TRAP
STEAM MAIN
UNCOVERED PIPE NOT LESS THAN 3'-0" LONG
UNCOVERED PIPE
RETURN MAIN
GATE VALVES
DIRT POCKET
GATE V.
TRAP
DIRT TRAP
WHERE IT IS NOT POSSIBLE TO RUN A VERTICAL COOLING LEG ON THE DRIP OF THE RISER, A HORIZONTAL PIPE MAY BE EMPLOYED

FIG. 2. VARIOUS ARRANGEMENTS OF STEAM RISER DRIPS FOR ONE MAKE OF TRAP

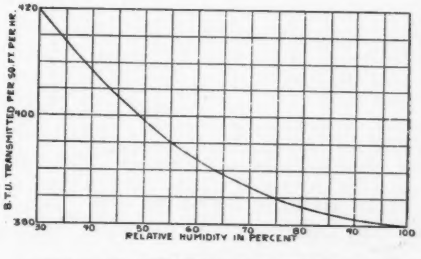


FIG. 4. EFFECT OF HUMIDITY ON HEAT TRANSMISSION

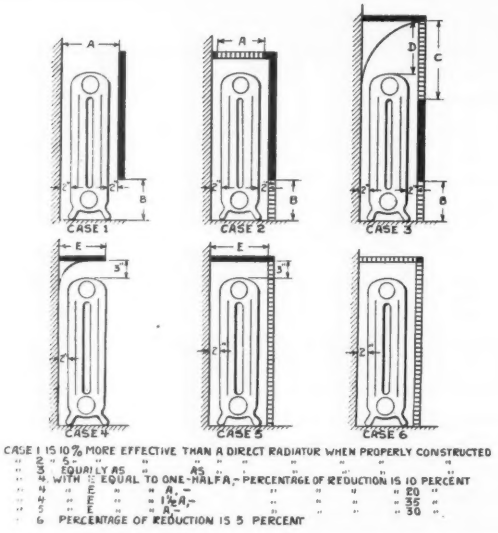

CASE 1
CASE 2
CASE 3
CASE 4
CASE 5
CASE 6
CASE 1 IS 10% MORE EFFECTIVE THAN A DIRECT RADIATOR WHEN PROPERLY CONSTRUCTED
" 2 " 5 " " " " " " "
" 3 EQUALLY AS " AS " " " "
" 4 WITH E EQUAL TO ONE-HALF A, PERCENTAGE OF REDUCTION IS 10 PERCENT
" 4 " E " " A " " " " 20 "
" 4 " E " " 1½A, " " " 35 "
" 5 " E " " A " " " 30 "
" 6 PERCENTAGE OF REDUCTION IS 5 PERCENT

FIG. 5. ARRANGEMENTS OF RADIATORS IN ENCLOSURES

of these, known as heat cabinets, use radiating surface much different from ordinary cast iron radiators and the two types should not be compared on the basis of area alone. In case it should be necessary for the engineer to enclose cast-iron column radiation, with the enclosures built as part of the architectural treatment of the room, the data of the A. S. H. & V. E. given in Fig. 5 may be of interest. They do not apply to any other types of enclosed radiation. Enclosed radiators of the types shown may give greater heating effect than exposed, because of the increased convection effect caused by the enclosure. As shown, however, care must be used in doing this if greater heating effect is sought.

It may be important for the industrial engineer to know the maximum condensation that takes place in a radiator when steam is turned on. Figure 6 shows test results on one radiator in which, 10 min. after steam was turned on, the maximum corresponded to about 3½ times normal condensation. Readings were taken at 10-min. intervals. The curve shows how the demand on the boilers, on starting the plant, may be much greater than the normal.

Amount of heat given off by a radiator may be increased by raising the velocity of the air over the radiator surface. This has been made use of in the hot blast heater and the unit heater, the principles of which are by this time well known to all engineers. Each of these employs heating coils through which a fan, located immediately adjacent to the coils, blows or draws air to be heated. Sometimes a direct fired unit heater is used, heat being generated by a fire in the heater. In most cases, however, the heating coils are supplied with steam just like a radiator.

In general, the hot blast heater is of comparatively large size to handle large volumes of air at a central point, the heated air being distributed by ducts. The unit heater is usually a smaller unit, several of them being placed at proper points in the room to be heated, to give even and adequate distribution of the heated air. One of the principal purposes in the design and location of the unit heater is to produce a circulation of properly heated air at the breathing zone near the floor, which is sometimes difficult with direct radiation. The unit heater allows great flexibility in installation, as it can often be supported from the roof, the building structure, or in some models, directly by the steam lines and return lines. It has also been applied to certain industrial drying processes.

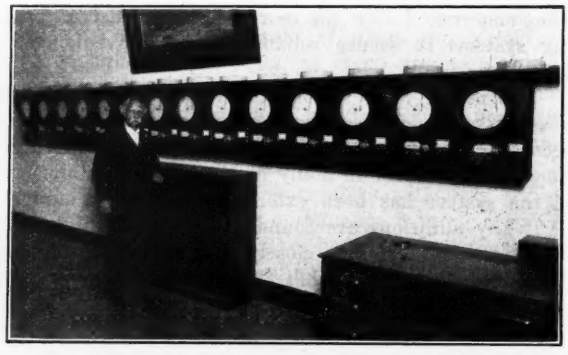


FIG. 9. STEAM FLOW RECORDERS FOR HEATING LINES IN SUPERINTENDENT'S OFFICE OF LARGE COMPANY

Fans on unit heaters and blast heaters require the same attention to lubrication, alinement and supports

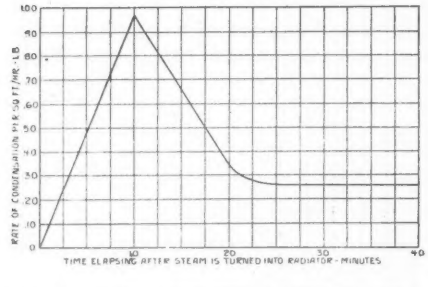


FIG. 6. CHART SHOWING MAXIMUM CONDENSATION IN HEATING UP A RADIATOR FROM COLD CONDITION

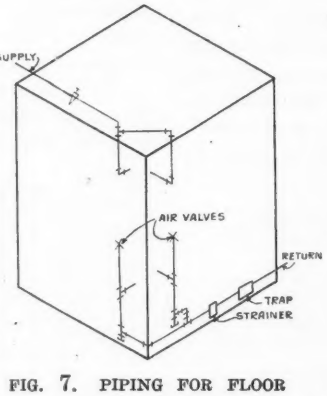


FIG. 7. PIPING FOR FLOOR TYPE UNIT HEATER, GRAVITY RETURN SYSTEM

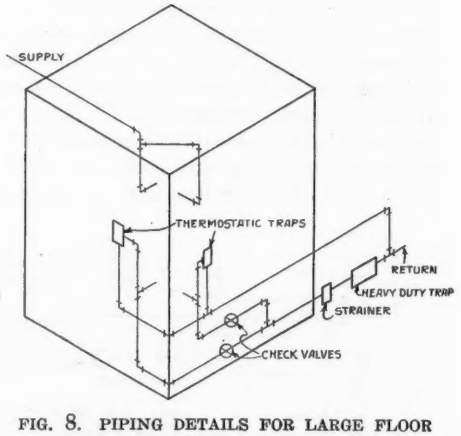


FIG. 8. PIPING DETAILS FOR LARGE FLOOR TYPE UNIT HEATER ON VACUUM RETURN SYSTEM WITH HEAVY DUTY TRAP

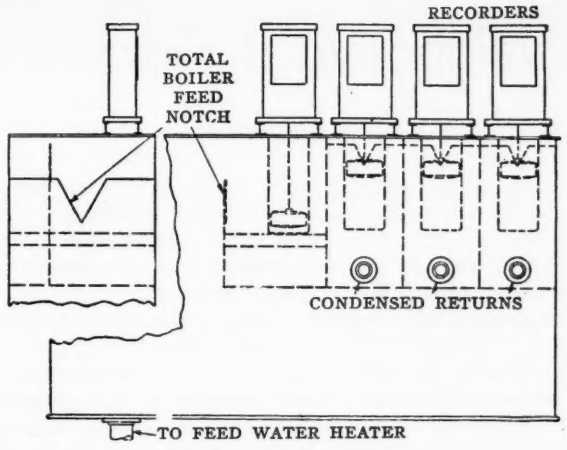


FIG. 10. MULTIPLE V-NOTCH METER MEASURING HEATING SYSTEM RETURNS

that they require on other applications. The same applies to their driving motors. In some of the larger types that rest on the floor, piping connections, especially the return lines, should be given some attention. Figures 7 and 8 show typical hookups of one type of unit heater designed to rest on the floor.

Some engineers have suggested the possibility of using unit heaters for cooling in summer by circulating brine through the coils instead of steam. This has not yet been done successfully and is not considered advisable; it would probably require coils of a different construction than those used for steam. Some cooling effect has been produced by circulating cold water through the heater coils and this practice has been followed in several installations. Also the heater fans have been operated as cooling fans alone.

Records Tell Where the Heating Steam Is Going

To distribute heating steam charges to the various industrial departments the engineer should have an adequate supply of steam measuring instruments. These should be used to the fullest advantage, otherwise they do not give the best return on the investment. It is common practice in some plants to place a recording flow meter on each heating line mounting the recorders of these together with kilowatt-hour meters for the electric lines on a central gage board in the office of the chief engineer, general manager or at other convenient

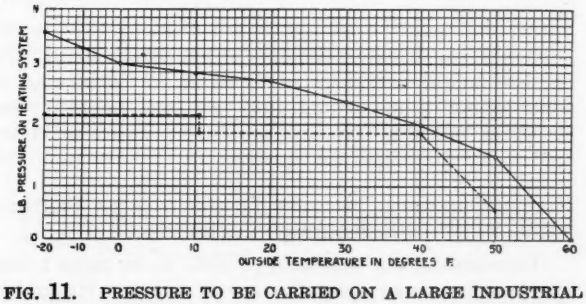


FIG. 11. PRESSURE TO BE CARRIED ON A LARGE INDUSTRIAL HEATING SYSTEM FOR VARIOUS OUTSIDE TEMPERATURES. WORKING DAYS, 6 A. M. TO 6 P. M. ——; SUNDAYS, HOLIDAYS AND WORKING DAYS, 6 P. M. TO 6 A. M.....

points, as in Fig. 9. Tests of various steam line pressures are also of value in determining the proper steam pressure to use on the system. In some large industrial plants, district heating practice is sometimes followed by placing a long distance recording pressure gage at the end of the system farthest from the steam supply, the pressure being varied according to this gage. Pressure can be allowed to vary with weather conditions, Fig. 11, showing the pressure-temperature curve used by a large industrial company. Where steam cannot be measured conveniently, it may be possible to measure condensate from the heating lines. Where all condensate is returned, this has some advantages. Individual lines can be handled with condensate meters or with V-notch meters; in either case the total amount may be led through a single meter to the boiler feedwater heater.

Muscle Shoals and Fertilizer Manufacture

IN THE first process of nitrogen fixation from air by electric arc, 67,000 kw-hr. were required for a metric ton of nitrogen fixed. This, as pointed out by Harrison E. Howe at the third meeting of the Southern Appalachian Power Conference, necessitated locating plants where large blocks of cheap power were available so that Norway became the home of the process in 1903.

Next came, in 1905, the cyanamide process, which used the electric furnace and reduced power requirements to 12,000 to 15,000 kw-hr. per ton of nitrogen fixed. This process spread rapidly, 36 plants being in operation in 1918 with output of 325,000 t. of nitrogen a year.

Use of a catalyst to induce combination of hydrogen and nitrogen into ammonia was demonstrated in 1912 as the Haber process and has since been improved and developed commercially. It requires 4000 kw-hr. per ton of nitrogen fixed.

At present, arc process plants have 44,750 t. capacity and output of 39,240 t. a year. Cyanamide process plants have 315,500 t. capacity and 174,250 t. output. Haber synthetic process has 663,010 t. capacity with 316,160 t. capacity under construction, and output is within a few tons of capacity.

Muscle Shoals was intended for the cyanamide process, to produce nitrogen for war time purposes. It was justified at that time for that purpose, as Haber's process had not then been brought to commercial perfection. Considered as a source of fertilizer, at the present time, it loses economic importance, first because the synthetic process gives a product better suited to the manufacture of fertilizers; second, because that process is cheaper.

With Chilean nitrate at $46 a ton, the cost of nitrogen it contains is $300 a ton. With by-product ammonium sulphate at $48 a ton, the cost of nitrogen content is $228.57 a ton.

It would seem, if the Government must make fertilizer for political reasons, that it would be better business to lease Muscle Shoals power on a basis to yield greatest returns and use those returns to produce fertilizers at such points and by such advanced methods as will give the most fertilizer at the lowest cost.

Recent High Pressure Development in Germany

PRESSURES ABOVE 1500 LB. AND BLOCK STEAM PLANTS FOR POWER AND MUNICIPAL HEATING SERVICE ARE BELIEVED TO BE MOST ECONOMICAL. BY DR. LOEFFLER*

FROM AN economical standpoint, the Diesel engine operated plant is at a disadvantage when compared to the high pressure steam plant burning coal, gas or oil according to the latest modern practice and the coupling of power and heating service. As the natural oil supply diminishes there will be an increasing economic competition between the users of the processes of gasifying, liquefying and powdering all grades of coal. Internal combustion engines have economic preference only when industrial wastes such as furnace,

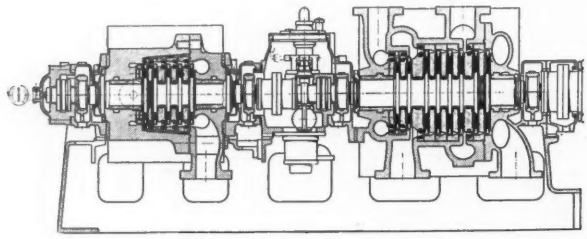


FIG. 1. TURBINES TO OPERATE AT 2734 LB. PRESSURE ARE UNDER CONSTRUCTION

illuminating or coke oven gas or cheap by-product oils from coal distillation are available.

Steam plant economy increases with the higher pressures. If powdered fuel is employed, it is important to preheat 20 to 30 per cent of the total air and feed it as primary air to speed and improve ignition and combustion. The cold secondary air may be passed through hollow walls for the purpose of cooling the furnace and it is best to use several burners of the type which mix the preheated air and powdered coal well while still in the burner.

In Berlin as high as 66,600 B.t.u. per hr. per cu. ft. of combustion space has been liberated by firing pulverized coal in a locomotive fire box. Accordingly, grate equipment in the boiler could economically and easily be replaced for powdered fuel firing, to assure quick and safe adjustment of the furnace fire to meet the boiler load. Picking of coal at the mine would be unnecessary. Preparation and delivery costs of powdered coal are low, and even the smaller boilers could obtain 10 to 20 per cent higher efficiency with powdered coal firing equipment in place of grates.

When a steam plant supplies both power and heat, utilization of the heat increases as the pressure is raised to the critical point. Pressures above 2200 lb. would hardly prove economical on account of the increased cost and need for special construction material. Forged steel drums are used for pressures above 450 lb. but for highest pressures specially prepared steel alloys are needed. Since under present machinery practice the cost of high pressure boilers is but little more than that of today's low pressure boilers, one may reasonably expect boiler pressures to be increased to 1500 lb. or more within a short time.

*Abstracted and translated from the V. D. I. Zeitschrift.

In modern heat economics, the aim is to couple power and heating requirements and to utilize the steam generated by expensive coal in high pressure power generating units and use the exhaust steam for heating or process work. The power and heating supply of a large city could be coupled conveniently with the operation of a distantly located coal mine. The coal could be dried at the mine with 70 to 200 lb. pressure steam exhausted from high pressure generating units designed to operate with steam at from 1500 to 1750 lb., supplied by powdered coal-fired boilers and of a size to supply sufficient exhaust steam for coal drying and perhaps for heating the mine. Whatever current is generated beyond the demands of the mine may be sent to neighboring communities.

Dried coal could be delivered unpressed to a number of district or block high pressure steam plants in the city as distributing of coal is cheaper than sending current where the distances are great. For a city such as Berlin block steam plants of 50,000 to 100,000 kw. capacity each would be considered, their location and capacity meeting the electric current and exhaust steam requirements of each district. The exhaust steam is used for municipal heating, cooking and also perhaps for small steam engines. Condensate is returned to the boiler feed and the electric current is used for lighting and power.

Block steam plants such as this would be interconnected by power transmission lines and under certain conditions the heating pipe line system might also be interconnected to assure an uninterrupted supply and to serve the community at low cost. If the use of

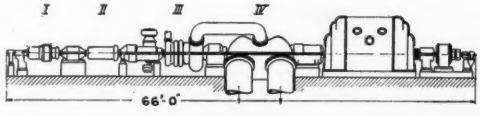


FIG. 2. A HIGH PRESSURE TURBINE DESIGNED TO USE STEAM AT 1764 LB. PRESSURE

exhaust steam decreases in the summer months the equipment of the plant may operate condensing under smaller load. In such a system, the cost for cable, piping and possible shutdown are reduced to a minimum. If the turbine in a block steam plant should fail, the loss would not be as great as if the turbine in a super power plant should fail, nor is it necessary to invest as much in standby equipment which must be held ready for immediate service.

HIGHER PRESSURES INCREASE POSSIBILITIES OF CENTRAL HEATING PLANTS

Increased steam pressures to 1500 lb. or more bring into much greater favor the use of exhaust steam for municipal heating than was possible heretofore. The greatest cost is in the piping system but at from 150 to 225 lb. the diameter of the pipes can be held down. If the district to be covered were larger, the pipe lines

would have to be longer and the diameter larger, which would mean increased cost. The block steam plant would eliminate this high cost and the rates of electric current would drop so low that the people would discard the use of gas. This is one reason why long distance gas supply systems should not be considered.

New Turbines Use Extremely High Pressures

For turbines above 5000 kw. capacity the high pressures effect a decided increase in efficiency. One 10,000-r.p.m. test turbine built for 1325 lb. pressure and 752 deg. F. operating with a Benson boiler at a back pressure of 191 to 206 lb., generates 1000 kw. and uses 22,046 lb. of steam per hr. Another 6000-r.p.m. turbine, shown in Fig. 1, intended to use 66,139 lb. of steam per hour from a Benson boiler at 2734 lb. pressure and 788 deg. F. and 96 lb. back pressure, when operating with 96 lb. back pressure and carrying a load of 3000 kw., will be placed in service about the middle of next year.

For small outputs the reciprocating steam engine will attain increased importance for the high pressure plant as well as an initial machine for low pressure plants. Therefore, one company has built a vertical, double-acting, two-cylinder engine with a capacity of 1000 kw. at 300 r.p.m. with 1764 lb. pressure, 914 deg. F. steam and a back pressure of 191 lb.

Turbines Preferable to Engines in Large Plants

In a larger plant the steam turbine is preferred. Figure 2 shows the construction and details of an 18,000-kw., 3000-r.p.m., high pressure turbine of the Erste-Brunner type, designed to use steam at 1764 lb. pressure and 914 deg. F. The high pressure rotor of the first stage will be enclosed by a two-section cast-steel housing. Steam enters at the left and leaves at 735 lb. at the right. The low pressure section of the turbine housings III and IV, Fig. 2, is already in service at 220 lb. pressure. The high pressure section of the turbine will be ready the middle part of this year. The boiler is being built and will be large enough to carry 5000 to 6000 kw.

The importance of high pressure steam operation is being recognized by railroads and steam ship lines, and the German government has ordered several high pressure locomotives of various types, either with or without condensing equipment, some with steam engines and some with turbines. It was stated recently at a German shipbuilding engineers' meeting that if steam pressures on ships were increased 30 to 40 per cent with present grate coal firing they would operate more economically than Diesel engine plants. Only after increasing the pressure, however, to 1500 lb. or more and introducing pulverized coal can the full benefit of high pressure steam operation be obtainable for marine work.

High Pressure Piping Causes Little Trouble

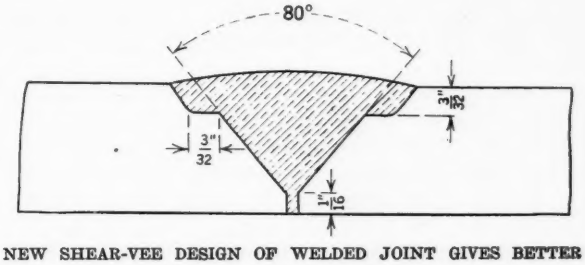
Prices given on page 1131 of the Nov. 1, 1927, issue, referring to welded joints are catalog list prices and, as called to our attention by one manufacturer, are subject to a considerable discount.

Bronze-Welded Joints for Cast-Iron Pipe

New Design Gives Strength Equal to That of Pipe

RESULTS of tests made public by the Linde Air Products Co. show that the collar type of bronze-welded joint for cast-iron pipe, much used heretofore and believed to be stronger than the plain vee type, has been over-rated. For de Lavaud type pipe the collar joint, under bending test showed only 55 per cent of the strength of solid pipe, fracture occurring in the pipe material at the end of the collar. For sand cast pipe the collar joint showed only 42 per cent of the strength of solid pipe.

With a plain vee joint, the strengths for de Lavaud and sand cast pipe were respectively 83 and 79 per cent those for solid pipe. For de Lavaud pipe, fracture took place in the joint, iron coming away with



NEW SHEAR-VEE DESIGN OF WELDED JOINT GIVES BETTER JOINING OF BRONZE TO PIPE END

the bronze near the inner surface of the pipe wall and bronze separating from the iron along the tinned surface, leaving a very thin coating of bronze on the pipe end. This showed the need of greater adhering surface in the joint and the shear-vee joint shown in the illustration was worked out. Tests of this joint showed strengths of 96 and 100 per cent that of solid pipe respectively for de Lavaud and for sand cast pipe. To get good tinning and adhesion, it is necessary to sear or anneal the machined ends, a requirement not formerly understood, which was the cause of the belief that the vee joint was weaker than the collar type.

This new type joint is easier to make than the collar joint and takes less welding material, so that the cost of the shear-vee joint, including machining and annealing pipe ends, is slightly less than for the collar joint but is greater than for the plain vee joint. Annealing should be done at the pipe manufacturer's plant as it is difficult to do a good job with the blow pipe in the field.

Even with the collar joint, only 2 per cent of joints failed in service, so, with the greater strength of the new joint, failures should be unknown. Internal pressure test showed that fracture took place lengthwise of the pipe, the joints appearing to be unaffected.

That welded joints pass stray electric currents better than mechanical joints and thus lessen tendency to corrosion is shown by the report of the U. S. Bureau of Standards that corrosion was no greater in or adjacent to welded joints than for any other part of the pipe line.

Small Turbines Popular for Auxiliary Drive

NEW DESIGNS FOR HIGH PRESSURES AND SPECIAL REGULATING DEVICES HAVE DONE MUCH TO INCREASE THE POPULARITY OF THIS TYPE OF DRIVE

DATA COLLECTED by the N. E. L. A. covering the application of steam turbine drives to auxiliary equipment shows a wide variation in respect to the service for which they were installed. Boiler feed pump drives total 33 per cent of all turbine installations reported, while condenser circulating pumps and condensate pumps are each credited with approximately 20 per cent of all installed. These are intended primarily for continuous service and are given preference to electrical drives from the standpoint of reliability.

With few exceptions the steam-driven auxiliaries are operated non-condensing to supply steam toward the maintenance of the station heat balance. The majority of the units are single units, although exceptions are found in some exciters and circulating pumps where dual drives are installed for reliability and heat balance control.

Various types of controls are used in conjunction with the usual speed governor control integral with the turbine unit. Their application to feed pump turbines to maintain a constant pressure differential between the feedwater pressure and the steam pressure have given satisfaction when used singly. When in parallel with other pumps, however, several companies reported unsatisfactory results, some going so far as to discontinue their use. Many of the installations have no control other than manual operation of the throttle valve for operation below normal governor speeds where requirements are such that constant speed is the normal operating point. With only two exceptions all are operated with overspeed trips set for tripping at an average of 10 per cent above normal speed.

THERMOSTATS CONTROL CIRCULATING PUMPS

Special operating features have been utilized by several companies. In one case the speed of the circulating pumps are controlled by an electrically operated thermostat set by hand to maintain the outlet temperature of the circulating water within 2 deg. F. of the predetermined temperature between the limits of 45 and 90 deg. F. The thermostat is set in accordance with the curve showing outlet temperatures for varying inlet circulating water temperatures.

Another company reports that its steam-driven hotwell pumps are equipped with a float to regulate steam admitted to the drive. This float is installed in the condenser hotwell and varies the turbine speed to maintain a constant hotwell water level under all operating conditions. In another installation where one boiler feed pump supplies a 1200-lb. boiler, the pump was equipped with a regulator to maintain constant drum level. Heavy oscillations were produced, making it necessary to redesign the regulator.

In general, the maintenance difficulties reported with auxiliary steam drives are few. The materials used in construction and the practice of periodic inspection, which is annual, or in case of extremely severe service, every three to six months, apparently prove a satisfactory safeguard and show reliable service records.

Periodic operation of standby equipment and testing of safety devices, the frequency of which is dependent upon the service for which the equipment is used, are additional precautions made use of by all companies. No troubles were reported due to corrosion of standby units and, accordingly, this has received little attention. Preventive measures, as steam drying and painting the interior to form a protective layer have been adopted by some companies.

HIGHER PRESSURES AND TEMPERATURES REQUIRED NEW TURBINE DESIGNS

Use of higher steam pressures and temperatures has made necessary the modification of the design of small steam turbines for this service. Much has been accomplished, but in some types defects in the design of governors, bearings and oil shaft packings must still be overcome. One company reports an installation of a 340-hp. turbine operating with 600 lb. gage and 700 deg. total temperature. This is the highest steam condition reported for service of this size.

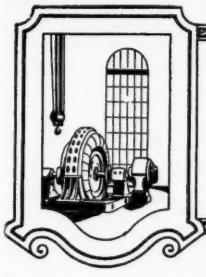
Necessity for satisfactory speed control is obvious, but apparently some manufacturers have neglected to take full cognizance of the seriousness of the present situation. This same applies to the overspeed governors which, on most types of machines, at the present time, are very unsatisfactory, due primarily to the erratic operation. In an effort to overcome the speed regulating governor difficulty, one manufacturer developed and placed in use on a small turbine a hydraulic type of control. Fifteen have since been applied to turbines used for generators driving up to 40,000 kw. capacity.

Lubrication trends are toward simplicity. With the highest steam temperatures the points of live steam admission are so located that the bearings are not subjected to direct heat by radiation or conduction, so that ring oiling has given satisfactory results. The development of the ejector pump by one manufacturer finds satisfactory application to the geared units used for auxiliary drives. Refinements in the alinement and in the manufacture of reduction gears makes it possible to use high speed turbines, allowing higher efficiencies in some installations where direct drives have been used in the past.

Definite lack of information with reference to economy, reliability and maintenance costs of turbines used for auxiliary drive exists. This may be due to the fact that spare capacity for use during maintenance periods is generally installed for this type of equipment with the result that outages are not of a serious nature and therefore not given considerable thought nor brought to the attention of power station management.

STATISTICS OF electrical output in Germany, now compiled for the first time, including not only public but all private industrial and agricultural power stations, show that in 1925 the electricity generated amounted to 20,300,000,000 kw-hr. or a total of 325 kw-hr. per capita.

NOBODY ever gained advancement by lying down on the job.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

The Reactive Component in A. C. Circuits*

PART I. INTRODUCTION, COMMERCIAL APPARATUS CLASSIFIED AND ANALYZED ON THE BASIS OF ITS POWER FACTOR CHARACTERISTICS. BY V. E. JOHNSON

WHEN AN ALTERNATING voltage is impressed upon the terminals of a circuit having magnetic characteristics, as, for example, a transformer coil, the flow of current is limited by the combined effect of the ohmic resistance of the conductors, and the counter electro-motive force induced in the coil by the cyclical variation in the flux. Maximum values for the ohmic drop and for the current occur simultaneously; the induced counter voltage comes to a peak at the moment of zero current because at this point the rate of flux change through the coil is the greatest.

There is accordingly a time interval between the corresponding points in the current and voltage waves, the amount of this displacement increasing as the ratio between the inductive and ohmic drops becomes greater. As a mathematical convenience it is assumed that the current in a circuit having magnetic characteristics lags *behind* the voltage (this assumption being made to distinguish it from the condition in a condenser where the current is said to *lead* the voltage). This lag is measured in degrees (a degree being 1/360 part of a cycle) and referred to as if it were an actual geometrical angle.

The power in such a circuit is proportional, not only to the voltage and current, but also to a third factor which varies with the displacement between them. This third factor is universally called the "Power Factor," and is equal to the cosine of the angle of lag (or lead).

In the single phase formula $W = E \times I \times \text{Cos } \Theta$, Cos Θ is the power factor, and $(I \times \text{Cos } \Theta)$ the power component of the current. It must be remembered, however, that the division of the current into the power component $(I \times \text{Cos } \Theta)$, and the non-power or wattless component $(I \times \text{Sin } \Theta)$ is purely a mathematical conception that has no electrical meaning at all.

The power factor is expressed as a fraction or in per cent. A circuit, for example, having 50 per cent power factor, is one in which the angular displacement is 60 deg, which, in a 60-cycle circuit, would mean a time lag of $60/360 \times 1/60$, or 1/360 of a second. A circuit made up of resistance only would have no displacement, and the power factor would be 100 per cent —the cosine of 0 deg. is unity. If it contained self-induction only, the displacement would be ¼ of a cycle (90 deg.) because the peak point on the voltage wave would correspond to the zero point of the current. The power factor would be Cos 90 deg. or zero deg.

*This is the first of a series of articles on this subject by the author. The next will appear in a subsequent issue.

The current taken by virtually any piece of apparatus has a reactive (sometimes called wattless) component that affects the performance and economics. Practically all commercial loads have resistance, inductance and capacity—a rigid division into classes is therefore impossible, but it is convenient to use the predominating characteristic in studying the phenomena involved. Accordingly, this discussion places them in four broad (and somewhat overlapping) divisions, as follows:

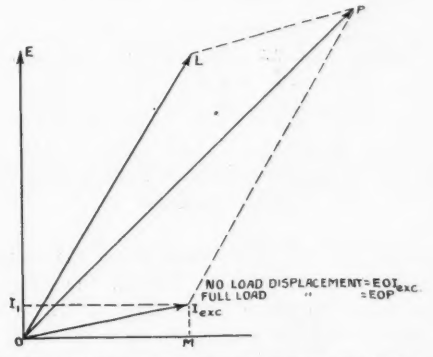


FIG. 1. LOAD IMPROVES THE POWER FACTOR OF A TRANSFORMER

I Loads consisting largely of resistance.
II Magnetic apparatus.
III Loads having condenser characteristics.
IV Apparatus which can be adjusted so as to partake of the characteristics of either II or III above, as for example, synchronous motors and related devices.

I. LOADS CONSISTING LARGELY OF RESISTANCE

Under this classification come incandescent lamps, resistors of various kinds, domestic and industrial heaters, consisting of resistance elements, and some special apparatus, such as water heaters, in which the current passes directly through the liquid.

An incandescent lamp or non-magnetic resistance heater connected directly across the terminals of a generator would constitute a load of very nearly unity power factor, as the phase displacement between current and voltage would be negligible. There would be some self-induction, and some capacity, but in such minute amounts as to produce no measurable effect. The power consumption would be equal to the product

of the volts and the amperes, and the wattless component would be zero.

Aside from industrial plants, there are few lighting installations in which the current is supplied directly from the generator terminals without the interposition of transformers. The use of the latter immediately introduces magnetic characteristics, and produces some phase displacement. This may, in long feeders, be neutralized by the capacity, but in any event the power factor will be high, and is, in fact, ordinarily assumed to be unity.

II Magnetic Apparatus

Under this broad classification come, with the exception of those listed under Class IV, all types of apparatus which operate through the agency of a magnetic field. Transformers, induction motors, regulators, reactors and induction furnaces are the most common examples.

Transformers

A transformer under no load conditions approximates closely a purely inductive circuit. The current OI_{exc} Fig. 1, taken from the line consists of two com-

KW.	POWER FACTOR 100% LOAD	75%	50%	25%
4	91.0	85.0	56.7	22.0
8	92.0	86.0	57.0	23.0
17	91.5	85.5	57.0	23.0
34	90.0	84.0	56.0	22.0
50	89.0	83.0	55.0	22.0

FIG. 2. CHARACTERISTICS OF STREET LIGHTING TRANSFORMERS

ponents, OM and OI_1, the former being the magnetizing or wattless portion, 90 deg. behind the voltage OE, while the latter, in phase with OE, represents the losses in the copper and the iron. OI_1 is very small so that the angle EOI_{exc} is almost 90 deg., with a corresponding power factor that approaches zero.

As load is added to the transformer, a new component, OL, is added, this representing in phase and magnitude the primary current that balances the secondary ampere turns. The angle EOL is determined by the power factor of the load on the secondary. The total primary current, OP, becomes displaced from OE by the angle EOP. Inspection shows that this is smaller than EOI, indicating that the power factor improves as the load increases.

The magnetizing current of a transformer is comparatively small, running from 2 to 5 per cent depending upon the size of the units; nevertheless, the aggregate effect upon the system is by no means negligible. During periods of light load, transformers use between 20 and 25 per cent of the total system wattless component, while during heavy loads about 10 to 15 per cent is chargeable to them.

Street Lighting Transformers and Feeder Regulators

Street lighting transformers of the constant current type, whether of the reactance or of the moving coil design, have a lower power factor than those used for constant potential power distribution. They are so constructed as to have considerable magnetic leakage, and therefore require more current for magnetizing purposes. Figure 2 gives a table showing the characteristics of a number of ratings.

Induction Motors

Induction motors, both squirrel cage and wound rotor, are magnetized by a component of the stator current at right angles to the voltage. This component increases with load, but not as rapidly as the total current, so that as the full rating is approached, the ratio becomes smaller, and the power factor better.

This is readily seen by referring to the published characteristics of such motors. Take, for example, a 25-hp., 3-phase, 60-cycle, 1760-r.p.m., 220-v. squirrel cage motor. The performance data are partially as follows:

Load	½	¾	Full	Increase from ½ to Full
Hp. output	12.5	18.75	25	100 %
Efficiency	87.5 %	89.5 %	90 %	
Kw. input	10.7	15.6	20.7	93.5%
Power factor ...	82 %	89.5 %	93 %	
Kv.a. input	13	17.5	22.3	71.5%
Reactive kv.a. ...	7.45	7.8	8.15	9.4%

The reactive kv.a. has increased only about 1/10 as fast as the horsepower. From the standpoint of power factor, it is evident that better operation is obtained by loading the motors to their rated capacities.

Group drives permit closer motor ratings if the diversity factor is good, but here again there may be

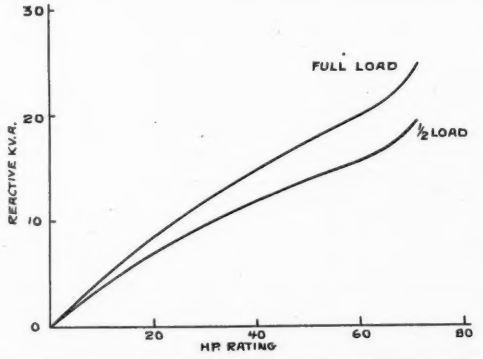


FIG. 3. CURVES INDICATING RELATION BETWEEN HP. RATING AND REACTIVE COMPONENT FOR DIFFERENT MOTOR SIZES

other losses introduced which more than offset the saving due to the higher power factor.

Figure 3 shows two curves indicating the relation between horsepower rating and the reactive component for different motor sizes. These are based on 220 v., 3-phase, 60 cycle motors, running at 1760 r.p.m. The larger motors have higher power factors and are preferable if the load conditions permit their use.

Figure 4 gives curves showing the relation between the speed and power factor of some 10-hp. induction motors. It will be seen that the 3600-r.p.m. machine has a higher full load power factor, and that the curve is much flatter. This general relation is due to the fact that power factor is a function of the magnetizing current, and this in turn is proportional to the ampere

turns required to maintain necessary flux through the iron and air gaps. The slower speed motors have more poles, more magnetic material and more air gap length, and as a result take more current to set up the fields.

It follows, therefore, that motors should be selected of the highest speed permitted by the mechanical limitations of the drive. For low speed work, it is often possible to substitute synchronous motors; this is particularly true in the larger sizes in which the cost for the same characteristics is lower than for the induction motor.

Miscellaneous Magnetic Apparatus

In addition to the two main classes of magnetic apparatus, as discussed above, there are a number of somewhat special types which operate at low power factors. Chief among these is perhaps induction furnaces; first, because the wattless component is large, giving a

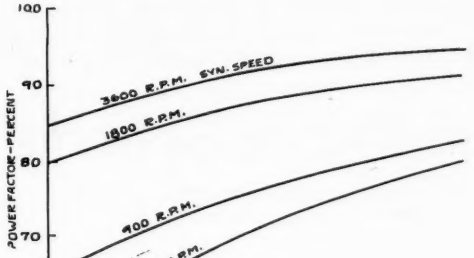


FIG. 4. CURVES GIVING RELATION BETWEEN SPEED AND P.F. OF 10-HP. INDUCTION MOTORS

power factor of about 75 per cent, and second, because the size of such installations is usually such as to exert a considerable influence on the system.

Reactors, welding machines and electro-magnets for various applications, come under this head, as do also the potential coils on watthour meters, relays and other instruments. The total wattless current taken by this subdivision is, however, relatively small, and exerts little effect on the operation or economics of the central station.

Effect of the Conductors and Feeders

Inasmuch as every conductor carrying an electric current is surrounded by an electro-magnetic field, it follows that even a straight wire has some self-induction and takes some wattless current. This is particularly true if several wires of a given circuit are widely spaced, and if they are carried in separate iron conduits.

On extensive systems the effect of the lines themselves may therefore be considerable; but obviously, in comparison to the other apparatus, it is small. Long transmission lines carrying heavy loads have considerable inductive drop; this being perhaps the only case where the magnetic effect is sufficient to enter seriously into the problem of low power factor.

III. Loads Having Condenser Characteristics

Aside from actual condensers, the most common example of this type of load is a long transmission line. The leading current taken by such a line is under some conditions very heavy, and complicates its operation considerably.

Figure 5 gives in tabular form some typical line constants. It will be seen from this that almost any commercial system will take considerable leading wattless current and will, therefore, to some extent, offset the lagging power factor caused by the connected loads.

IV. Apparatus with Adjustable Phase Relations. Synchronous Motors

The principal type of apparatus with adjustable power factor is the synchronous motor. Its application comes under three general classes, as follows:

A. Synchronous motors operating at 100 per cent power factor, and of a rating exactly equivalent to the mechanical load.

B. Synchronous motors designed to carry a mechanical load, and at the same time to be capable of supplying corrective leading or lagging current.

CHARGING K.V.A PER MILE OF A NO. 0000 LINE

20 KV.	4 FOOT	SPACING	2.59	K.V.A.
40 KV.	5 "	"	9.93	K.V.A.
70 KV.	7 "	"	28.6	K.V.A.
200 KV.	21 "	"	196.0	K.V.A.

(TAKEN FROM "ELECTRICAL CHARACTERISTICS OF TRANSMISSION LINES" BY WILLIAM NESBIT)

FIG. 5. TYPICAL LINE CONSTANTS

C. Synchronous motors designed to operate without mechanical load for the sole purpose of correcting power factor.

The value and phase position of the stator current taken by a synchronous motor can, by means of field manipulation, be varied within comparatively wide limits imposed by the rating and the design. This characteristic provides a convenient means for accurately controlling the output of corrective kilovolt-amperes. It is commonly (though somewhat inaccurately) referred to as "supplying leading or lagging wattless current to the line"—a rather convenient conception, in that it

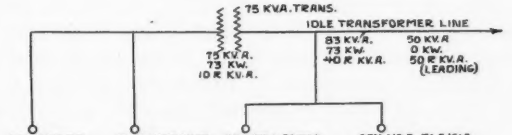


FIG. 6. TYPICAL MIXED FEEDER WITH THE POWER AND REACTIVE COMPONENTS APPLYING TO THE VARIOUS PORTIONS

gives a concrete meaning to the phenomena involved, and permits a ready quantitative analysis of the power factor conditions on the system.

Within the last few years there has been developed and marketed a new type of motor variously designated as "compensated", "unity power factor", and "synchronous" induction motors. These ordinarily have a commutator which delivers a direct current into the secondary windings. The power factor is not readily adjustable, but the proper amount of correction is obtained by a proper balance between the active capacities of the compensated and non-compensated types.

Synchronous converters come under a rather special classification, in that in them the adjustment of phase relations is possible, but not desirable, except perhaps within exceedingly narrow limits.

Looked upon as a driven machine, the rotary converter partakes of the characteristics of a synchronous motor; the value and phase position of its stator current can be controlled by field manipulation. Operation at any except unity power factor is, however, undesirable, due to the fact that the "out of phase currents" cause undue heating in the tap coils to which the commutator bars are connected.

This excess heating varies somewhat with the design of the machine, but in any of the modern, closely rated machines it is apt to damage the insulation, except at times of light load. The sensitiveness of this apparatus to wattless currents is so great as to have necessitated the use of reactive factor meters in place of power factor meters, in order to read with extreme accuracy the displacement in the neighborhood of unity.

It is evident from the foregoing that all electrical apparatus has power factor characteristics that are determined by inherent relations between their resistance, inductance and capacity, and, in another sense, by the operating conditions. Obviously, too, the characteristics of the entire electrical system will be a resultant of the phase relations of the component apparatus, and will vary widely. It has been estimated that the portion of the system which serves to transmit and distribute the energy utilizes 15 and 30 per cent of the total reactive current, that the transformers (as has been stated) take from 10 to 25 per cent, and that the utilization apparatus uses from 45 to 75 per cent of it.

Figure 6 shows in schematic form a typical mixed feeder, with the power and reactive components applying to the various portions. It will be noted that each unit has its own phase relations as determined by its inherent characteristics, and that the bus power factor is the resultant obtained by combining these. The total kilovolt-amperes required by this feeder is supplied by the two generators operating in parallel on the bus.

Electric Circuits and Distribution Systems

PART II.* POWER LOSSES IN ELECTRIC CIRCUITS, METHODS OF CALCULATION AND MEASUREMENT, INSTRUMENTS USED IN TESTING

OBVIOUSLY the power lost in an electric circuit is the difference between the power delivered to the circuit and the power delivered by that circuit at the receiving end. The power lost in any circuit, however, is dependent upon various factors such as length of the circuit, size of conductor, amount of power transmitted, number of transformations and efficiencies of transformers, etc. In any conductor, the power lost, is always

$$P = I^2 \times R$$

where P is the power in watts, I the current in amperes and R the resistance of the conductor in ohms. This equation is perfectly general and applied to all direct current circuits and all alternating current circuits of ordinary voltages and frequencies. Thus to measure the power lost in any conductor, it is merely necessary to determine the resistance by direct measurement or by calculation and then to measure the current flowing in the conductor under normal load conditions. The power loss is then arrived at by means of the foregoing formula.

While this method is possible it is usually easier in the case of ordinary power circuits to measure the input at one end of the circuit by means of voltmeters and ammeters or wattmeters and also the output at the receiving end by the same means. These measurements, of course, should be taken simultaneously and with instruments sufficiently delicate and accurate to measure the relatively small amount of power lost compared to that transmitted. This method has the advantage of including all losses, line loss and transformer losses in one operation.

If it is desired to determine the power loss by the I^2R method, however, several methods and instruments are available for measuring the resistance of the line. Resistance measuring devices include wheatstone bridges, megohmers and voltmeters. The wheatstone bridge is a combination of conductors wherein the unknown resistance (in this case the line) is compared directly to a standard resistance without the use of calibrated measuring instruments. The typical schematic diagram of the wheatstone bridge is shown in Fig. 3. A, B and R, are known variable resistances. X is the unknown resistance. When resistances A, B and R are so adjusted that the reading of the galvanometer is zero when both keys are closed, the resistance X can be found by the following formula.

$$X = R \times (A \div B)$$

where X is the resistance in ohms of the conductor to be measured and R, A and B the resistances in ohms of the respective arms of the bridge.

Wheatstone bridges are made in various forms for both field and laboratory use and before selecting an instrument of this type for a specific use, it is well to investigate the adaptability of the instrument for the purpose desired.

For ordinary measurements in the power station the slide-wire type of bridge often proves useful since it is well adapted to the measurement of low resistances.

MEASUREMENT OF ELECTRIC POWER

Electric power delivered to circuits or by circuits may be measured either by wattmeters or by voltmeters and ammeters. In direct current work a voltmeter and ammeter are sufficient but in alternating current work a voltmeter and ammeter will not give correct power values unless the power factor of the circuit is known.

In direct current circuits all power in watts is equal to the products of the volts times the amperes. This also

*Part I of this article appeared in the January 15, 1928, issue, page 139.

holds true for a single phase alternating current if the power factor is unity. Where the power factor is other than unity the power is equal to the volts times the amperes times the power factor.

In a three phase circuit the power is given by the formula

$$P = E \times I \times P.F. \times \sqrt{3}$$

where P = the power in watts, E, the voltage across the lines; I, the line current in each of the three wires and PF, the power factor of the circuit in per cent.

There are two ways of measuring the power in a three-phase circuit by means of wattmeters, i. e., the three wattmeter method shown in Fig. 4 and the 2 wattmeter method shown in Fig. 5. The first method is self-evident; the power is measured in each phase separately and the results added together. This method gives correct results for total power under all circumstances whether the load is balanced or not.

Since the neutral point is not always accessible, the two wattmeter method is the one generally used in practice. This method is based upon the fact that any of the three wires may be considered as a return wire for the currents flowing in the other two. With the wattmeter connections shown in Fig. 5, the wire B is taken as the return wire, so that the three-phase system is reduced to two single phase systems AB and CB. The

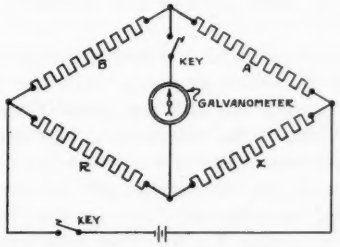


FIG. 3. SCHEMATIC DIAGRAM OF A WHEATSTONE BRIDGE

power in the first system is proportional to the current in A times the voltage between A and B. The power in the second is proportional to the current in C times the voltage between C and B. The wattmeters are connected so as to measure the power according to these expressions. The total power is equal to the sum of two simultaneous wattmeter readings and the method is correct with balanced as well as with unbalanced loads.

When the current and voltage is higher than that for which the measuring instruments are designed, current and potential transformers may be used. If R_w is the reading of the wattmeter, C the ratio of the current transformer and P the ratio of the potential transformer,

$$\text{True watts} = P \times C \times R_w$$

In measuring the power in a two-phase circuit each phase should be considered as a separate single phase circuit. The sum of the readings on two wattmeters gives the total watts.

When using the two-wattmeter method in a three-phase circuit, it must be understood that it is the algebraic sum of the wattmeter readings that gives the correct result. The higher reading wattmeter is always positive; the lower reading one is positive if the power factor is above 0.5, negative if it is below 0.5. To determine by test whether this latter reading is positive or negative, open the line to which the wattmeter in question *is not connected.* This leaves a single phase circuit on the wattmeter; if the wattmeter still reads forward, it will give positive values on the three-phase connections. If it reads backward, it gives negative readings on three phase.

Power Delivered to Motors

To obtain the most economical performance of electric motors, it is necessary that the size of the motors

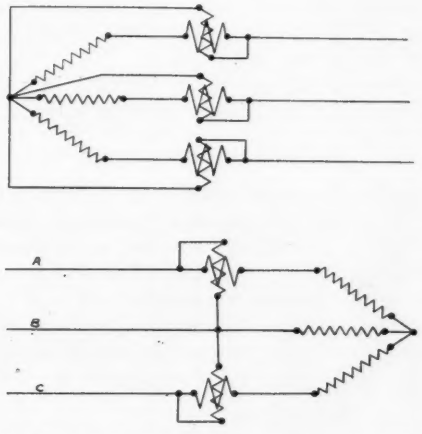


FIG. 4. THE 3 WATTMETER METHOD OF MEASURING 3 PHASE POWER

FIG. 5. THE 2 WATTMETER METHOD OF MEASURING POWER

be no larger than required to drive the load. There is a tendency on the part of the machine manufacturers to overestimate the horsepower required and to recommend motors of larger size than necessary. Where such motors are installed, they operate normally at a fraction of full load and at correspondingly reduced efficiency. In a large plant the total of the motor losses together with the interest on the added capital investment necessary to cover the larger sized motors may amount to a considerable monetary loss.

To determine the actual power delivered to a motor, the best method is to drive the machine in question and then measure the electrical input to the motor by any of the methods described above. To determine the actual power required to drive the load there should be subtracted from the input to the motor, the power loss in the motor itself.

The power loss in the motor may be determined experimentally or from the efficiency curves furnished by the manufacturer. If the losses are to be determined by test, several arrangements are available. The power input may be determined electrically and the output may be measured directly by means of a prony brake. The motor loss at any load then, is the input minus the output. If two machines of the same size are available, the opposition method may be used. In this case all machines are connected mechanically and electrically and the total losses supplied from an external source. Figure 6-a shows a method for supplying the losses mechanically. One machine acting as a generator sup-

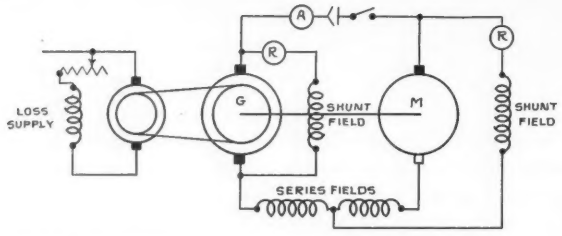


FIG. 6. METHOD OF DETERMINING MOTOR LOSSES BY SUPPLYING THE LOSSES MECHANICALLY

plies the other machine acting as a motor. The motor, being mechanically coupled to the generator, makes it necessary to supply from an external source only the power lost in the two machines.

A similar arrangement can be used in which the losses are supplied electrically from an external source.

Transformer Regulation

Regulation of a transformer is the difference between the full load and the no load secondary voltage for the same primary voltage, expressed as a percentage of the full load secondary voltage. Thus, if a transformer gives its rated secondary pressure of 110 v. at full non-inductive load, and the voltage rises to 113 v. when the load is thrown off (the primary voltage being kept constant) the regulation of this transformer is

$$\frac{113 - 110}{110} = 2.73 \text{ per cent}$$

Regulation is of considerable importance, particularly in the case of lighting circuits, where a difference of even two per cent between the no-load and full-load voltages is quite appreciable in the quality and quantity of the light given by the lamps.

Regulation may be determined directly by exciting the transformer at rated frequency and with a primary voltage such that rated secondary voltage is obtained at full load using lamps or a water rheostat as load. The increase in secondary terminal voltage from full load to no load is then observed. This method, however, is unsatisfactory because of the small difference between the full-load and no-load values. Much more reliance can be placed on results calculated from separate measurements of impedance drop and resistance. A number of methods have been proposed but the following formula will be found simple and practically correct.

$$\text{Per cent regulation} = p\,RI + q\,XI + \frac{(p\,XI - q\,RI)^2}{200}$$

in which RI is the total resistance drop in the transformer due to load current expressed in per cent of rated voltage; XI is the total reactive drop due to load current similarly expressed; p is the power factor of the load on the secondary and q is the reactive factor of the load.

Transformer Losses

Transformer losses may be classified under two headings, iron losses and copper losses. The iron losses are practically the same at all loads. They depend upon the frequency and range of the flux density, upon the quality and volume of the iron and upon the thickness of the laminations.

The copper loss is the I^2R loss in the windings and is expressed by the formula

$$W_c = R'\,I'^2 + R''\,I''^2$$

where $R'\,I'$ and $R''\,I''$ is the resistance and current in the primary and secondary, respectively.

The efficiency of a transformer is the ratio of its net power output to its gross power input, the output being delivered to a non-inductive circuit. The power input includes the output together with the losses referred to above.

Iron loss in watts is found by inserting a wattmeter in the primary circuit of a transformer and reading its deflection. This gives the iron loss plus the I^2R loss in the windings. Knowing the resistance of the circuit, the I^2R loss can be taken out and the remainder is the iron loss.

Often a refinement of this measurement is advisable. This consists in subtracting not only the I^2R loss of the existing current but also the losses in the voltmeter and pressure coil of the wattmeter. The core loss in a transformer, however, varies with the wave shapes of the alternator supplying the current and for accurate work account should be taken of this. In Fig. 7 is shown a diagram of connections which does this using an iron loss voltmeter. The iron loss voltmeter should be connected in circuit with a root-mean-square voltmeter; both readings should be noted and correction made for the loss of the wattmeter from the readings of the r.m.s. voltmeter.

In Fig. 8 is shown the connections for obtaining the copper loss and impedance drop. The current should be adjusted with the voltmeter and the wattmeter shunt winding disconnected. The wattmeter may then be read first, followed by the voltmeter. By dividing the copper loss by the rated output, the effective IR drop expressed as a fraction of the rated voltage will be obtained. Divide the observed voltage by the rated voltage and the effective impedance drop expressed as a fraction of the rated voltage will be obtained.

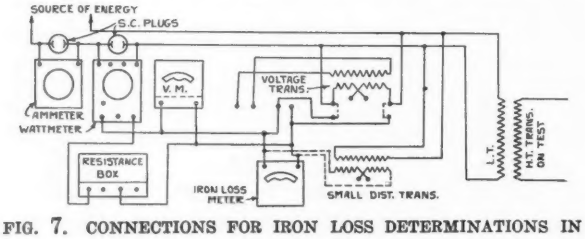


FIG. 7. CONNECTIONS FOR IRON LOSS DETERMINATIONS IN TRANSFORMERS

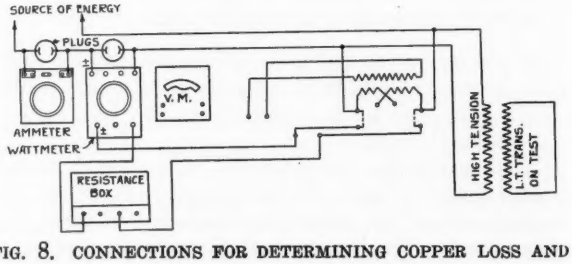


FIG. 8. CONNECTIONS FOR DETERMINING COPPER LOSS AND IMPEDANCE DROP IN TRANSFORMERS

Gasoline Engines Built for High Powers

ECONOMICS OF OIL AND GASOLINE PRODUCTION CAUSES STERLING COMPANY TO BUILD GASOLINE ENGINES IN LARGE UNITS

ALTHOUGH the trend has been toward use of oil rather than of gasoline engines for large powers, large bore, high speed and high duty gasoline engines are now being constructed by the Sterling Engine Co. of Buffalo, N. Y. These are six and eight-cylinder engines with 8-in. bore and 9-in. stroke, developing in a six-cylinder model, 425 br.hp. at 1200 rev. and 565 br.hp. in the eight-cylinder at 1200 rev. These horsepowers were developed on the test block under regular running conditions and if corrected for barometric pressure and altitude, the sea level power would run considerably higher. An advantage claimed for the gasoline is increased speed due to greater ease of obtaining a proper combustible mixture. This higher speed permits of smaller size and weight and reduced cost for a given horsepower.

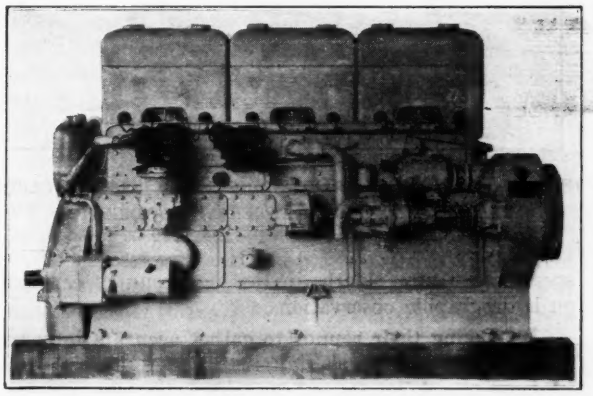
Back of the development indicated is a thorough analysis of the fuel situation as it pertains to both oil and gasoline, and the confirmed assumption that gasoline engines in large sizes will be continued in increasingly heavy demand as long as the fuel is derived from crude oil. Studies were made of the actual running cost of oil engines versus gasoline engines, taking into consideration the price of oil fuel at $0.085 per gallon delivered. The development of the new cracking process renders an excellent grade of fuel available at $0.14 a gallon delivered, a price that makes the running cost comparable with that of oil.

The new Sterling engines are built with iron crank cases and weigh about 15 lb. per rated horsepower, excluding batteries, but including electric starters and generators. The bearings are fitted without shims, entailing accurate workmanship and rigid construction. The crank shaft is counter-weighed and and dynamically balanced. The cylinder casting is a long water jacket in which the cylinder liners are inserted. This construction enables the making of removable cylinder liners of uniform thickness which may be operated at an even temperature. The cylinders project down into the upper crank case, guiding the piston the full length of the stroke and balancing the fastening near the center of piston travel. The cylinder heads are made in pairs and can be detached without disconnecting the exhaust line or the fuel piping or manifolds. Connecting rods are 18 in. long on centers, with main bearings 4 in. in diameter, 3⅜ in. long. Oil is carried under pressure to the piston pin and to all main bearings. connecting rod bearings and cam shaft bearings. This oil is forced through a cooler attached to the side of the cylinder block and also strained through oil purifiers. These piston pins, which are tubular, are cut from solid nickel-chromium steel 2 in. in diameter.

Tendency to wear the guide hole oval and thus cause an excessive amount of oil to drain down the valve stem and flood the valve, is avoided by interposing a member between the rocker arm and the valve stem so that thrust on the valve is directly downward. Roller type push rods are employed and dual valves are used in the head.

The cooling system consists of a large bronze water pump with aluminum bronze gears. The water is pumped first to the cooling header on the side of the cylinder block, where it functions to cool the oil, and then out through holes that are provided to inject the water under pressure in the cylinder block between cylinders. The water then passes up through internal passages, protected by brass ferrules set in cork (to prevent electrolysis) and, under a state of turbulence, carries the heat out of the cylinder head, which is provided with large cooling capacity.

Inlet and exhaust manifolds are integral, the exhaust being water jacketed and by this arrangement hot spots are provided just above the carburetors, which correctly gasify the fuel. The ignition can be provided for either 12 or 32 v. and consists of four distributors each firing four spark plugs per cylinder. All the plugs



HIGH SPEED AND COMPACT DESIGN ARE COMBINED IN THE PRODUCTION OF HIGH POWERED GASOLINE ENGINES

are in action but in the event of one or more systems being down, the remainder would operate the engine. Fuel efficiency under three-quarters to full load conditions is 0.65 lb. per br.hp-hr. Three carburetors are used for the six-cylinder engine and four for the eight-cylinder engine.

THE UNITED STATES CIVIL SERVICE COMMISSION announces an open competitive examination for Junior Engineers at a salary of $1860 a year. Application for this must be on file with the Commission not later than February 25. The duties of these positions are to perform routine testing, inspection of engineering material, drawing up plans for minor projects, preparing of specifications, etc. Examination will be given in several optional subjects including aeronautical engineering, agricultural engineering, chemical engineering, civil and mining engineering and the like. Competitors will be rated on general physics, mathematics, general engineering and the optional subject selected.

Full information may be obtained from the United States Civil Service Commission at Washington, D. C., or the secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

San Joaquin Hydrographers Obtain Valuable Data

MEASUREMENTS OF SNOW AND STREAM FLOW CONDITIONS INVALUABLE TO POWER COMPANY AND IRRIGATIONISTS ARE MADE ALL WINTER BY HYDROGRAPHERS WORKING UNDER MANY HARDSHIPS. BY C. W. GEIGER

INFORMATION of value to irrigationists and the San Joaquin Light & Power Corp. is obtained at considerable expense to the company and under conditions of hardship on the part of two hydrographers who

FIG. 1. HYDROGRAPHER STANDING NEAR ROOF OF CABIN THAT WAS BURIED UNDER A SNOWDRIFT

spend the winter months in the high country carrying on hydrographic observations.

In making their rounds to gather accurate information on snow conditions and stream flow, these hydrographers travel on snowshoes approximately 375 mi. each month, carrying on their backs a pack containing record books and measuring instruments. In the area under observation are six stations, from 8 to 20 mi.

FIG. 2. WEIGHING THE SNOW FROM A "SNOW-THIEF" TO DETERMINE DENSITY

apart. Cabins have been placed at five of the stations where the men rest and prepare meals. Once each month they come down to Balch Camp, a distance of 25 mi. from Cliff Camp, the headquarters. The trip requires three days, one day coming, one day for rest, and one day for the return trip. These are the only periods of contact with the outer world afforded the hydrographers during the winter months. Newspapers, letters, magazines and small items necessary for their work or pleasure are carried back on foot.

Nevertheless, the life of the hydrographer is not as monotonous as might be supposed. He must cook his own meals, keep his house and maintain his equipment in repair between trips to various stations under observation.

Following a characteristic tour of inspection, the men leave Cliff Camp, elevation 6500, at night. Night travel is preferred as the snow is harder on the surface and glare from sunlight on the snow is avoided. The first stop is at Helms Cabin, 10 mi. from Cliff Camp, where observations are made and rest taken before a trek of 13 mi. to Meadowbrook Cabin, which is at the extreme south of the area under observation at elevation 8000. The return to Helms is made the following day and rest obtained before a 25-mi. hike across country to Dinkey Station at elevation 5500 ft. From Dinkey to Deer Creek is but eight miles but a lot of it is stiff climbing, which makes a rest over night at the Deer

FIG. 3. GAGING STATION CONTAINING INSTRUMENTS AT CLIFF CAMP

Creek Cabin quite welcome. Another eight miles takes the men to Cliff Camp, their starting point. Thus far five stations have been covered, but there yet remains Rancheria station, six miles from Cliff Camp, which is reached in one day. Four observations are made each month at the lower stations and two per month are sufficient at the upper stations while the streams are frozen. This schedule keeps the boys moving, especially during stormy weather when blizzards may hold up observations for several days at a time.

The depth of the snow is found by checking on a gage or marked tree or by inserting in the snow a tube known as a "snow-thief." The contents of the tube are weighed to determine the water content. Streams are gaged by automatic recording instruments installed in stations built of stone near the stream, as in Fig. 3.

It is during the spring and early summer that the hydrographer is busiest. As the snow melts and the streams increase in size, the gaging stations must be carefully watched to be sure the instruments are not flooded. In such an emergency, measuring devices must be improvised, consisting of nothing more than a mark on a rock or a stick inserted in the water. By noting the water level at regular periods, the stream flow is calculated later.

Applications of the Ammonia Performance Chart

STANDARD VALUES OF REFRIGERATING EFFECTS. DESCRIPTION OF THE PERFORMANCE CHART, APPLICATIONS AND CALCULATIONS. BY W. R. WOOLRICH*

IN SOLVING PROBLEMS in refrigeration, the use of the Ammonia Performance Chart shown herewith is of great convenience. It enables one to visualize the effect that a change in any one of the various temperatures and pressures in the refrigeration cycle upon the others. Before discussing the use of this chart it may be desirable to define the recognized standardized values of refrigeration. These are:

1. The removal of 200 B.t.u. per min. for 24 hr. is equal to one ton of refrigeration.

This is based on the latent heat of fusion of ice taken as 144 B.t.u. per lb. or 288,000 B.t.u. per t. The removal of 288,000 B.t.u. in 24 hr. or 1440 min. is equal to the removal of 200 B.t.u. per min.

2. The standard ton of refrigeration is based on an inlet pressure of 19.57 lb. gage with its corresponding saturation temperature of 5 deg. F. with 9 deg. of superheat; this to be measured within ten feet of the compressor inlet. This gives a superheated temperature of 14 deg. F. for standard inlet conditions. The heat content under these conditions is 618.7 B.t.u. per lb. of ammonia.

3. The compressor discharge temperature for standard ton conditions is 86 deg. F. with its corresponding saturation pressure of 154.5 lb. gage, and with 136.6 deg. F. of superheat measured within 10 ft. of the compressor outlet. This gives a superheated temperature of 222.6 deg. F. for standard outlet conditions. The heat content of a pound of ammonia under these conditions is 720.6 B.t.u.

4. The temperature for standard ton conditions measured within 10 ft. of the expansion valve is 9 deg. F. below the saturation temperature at 154.5 lb. gage. Since the saturation temperature is 86 deg. F. the 9 deg. F. of subcooling gives a standard liquid temperature of 77 deg. F. The heat content of a pound of ammonia under these conditions is 128.4 B.t.u.

5. The heat content difference before entering and after leaving the evaporator or cooler, found by subtracting the heat content of one pound of ammonia just before it passes through the expansion valve from the heat content of the same pound of ammonia just before it enters the compressor inlet valves is known as the Refrigeration Effect.

The standard ton refrigerating effect will be, then, the difference between the two standard values given above or 618.7 — 128.4 or 490.3 B.t.u. per lb. of ammonia.

6. The amount of ammonia required to be pumped per ton of refrigeration per minute can be found by dividing 200 by the value of the refrigeration effect.

7. The volume of one pound of ammonia at standard superheated inlet conditions is 8.343 cu. ft.

8. The volume of one pound of ammonia at standard superheated outlet conditions is 2.412 cu. ft.

9. The entropy value of the superheated vapor under standard ton conditions is 1.3368.

*Professor of Mechanical Engineering, University of Tennessee.

For other than standard conditions it is difficult from tables to visualize what effect any one change in the several temperatures and pressures of the refrigeration cycle might have. The Ammonia Performance Chart is a complete graph that will give the values desired directly in B.t.u.

THE AMMONIA PERFORMANCE CHART

The several scales of the performance chart shown on page 190 are as follows:

1. The base scale is given in gage pressure of the ammonia in pounds per square inch.

2. Constant temperature lines are shown in dash. They are nearly horizontal in the region below the liquid ammonia curve, then in the region of the mixture of ammonia liquid and vapor, they are vertical and their respective lengths represent the latent heats at the different pressures. When vaporization is complete, the lines of superheated ammonia incline diagonally upward to the ordinate axis.

3. The constant quality lines show a convergence at some point beyond the range of the chart which is characteristic as they approach the critical pressure region.

4. The curved constant entropy lines of compression are given for values from 1.30 to 1.40. It is between these values that nearly all practical performance tests are made.

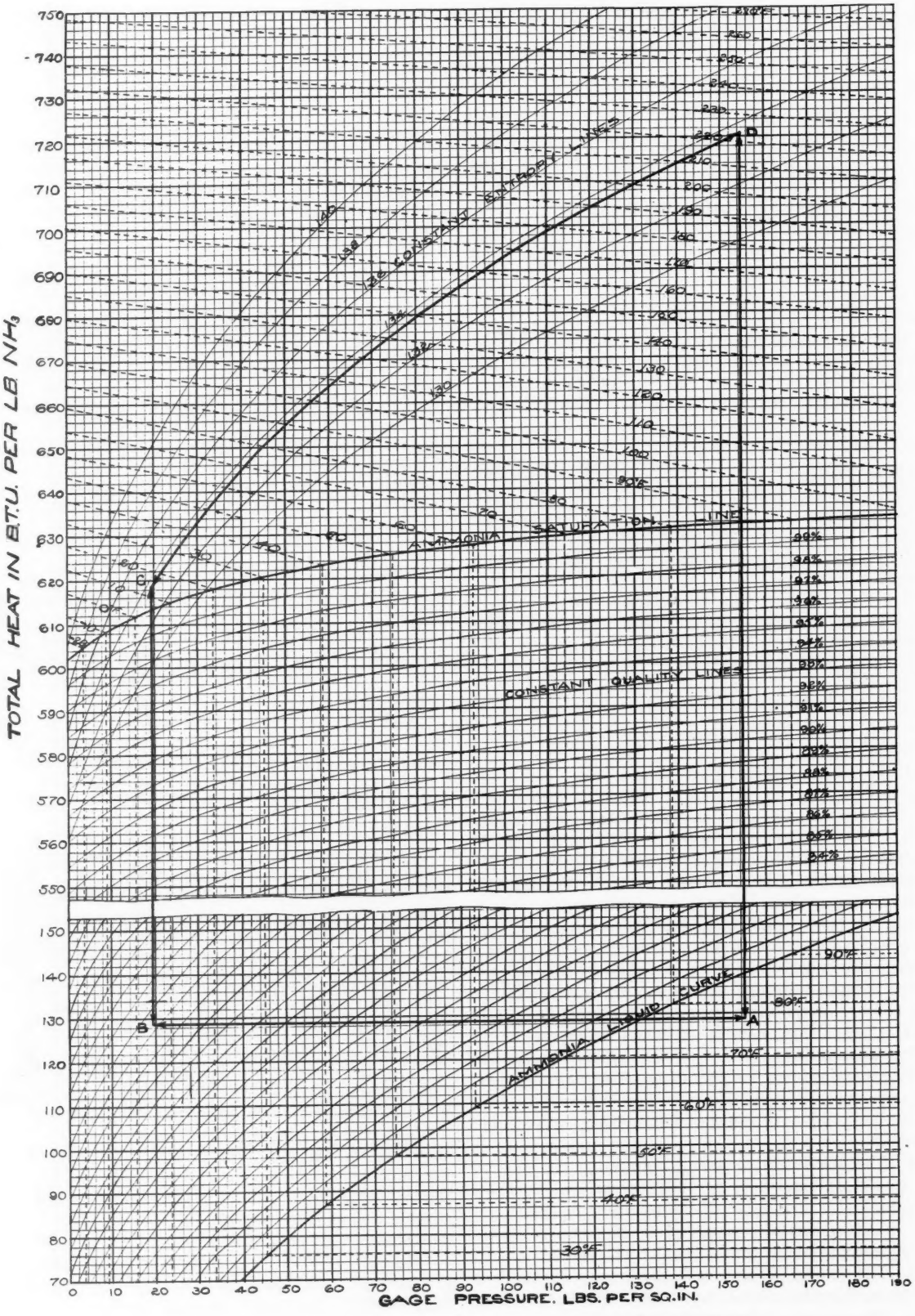
5. The vertical or ordinate axis gives the total heat in B.t.u. per lb. of ammonia, the lines of constant heat value extending horizontally across the chart.

The heavy diagram traced on the chart is the complete cycle of the "standard ton values" as adopted by the American Society of Refrigeration Engineers.

To trace out the values given in the heavy diagram, start with the value of the standard receiver or expansion valve temperature of 77 deg. F. As the ammonia passes through the expansion valve, the temperature drops very quickly as is shown by the heavy line A-B crossing over the several constant temperature lines and passing to the right until it reaches the "standard ton" inlet pressure line of 19.57 lb. gage. In this pressure drop and temperature change, however, the heat value has remained practically constant.

At point B the ammonia starts absorbing heat from the brine or room, without any change in temperature. The B.t.u. rises perpendicularly as the ammonia takes up heat without any change in gage pressure. This is shown on the diagram by the vertical line B-C. During this change the quality of the ammonia changes from that of a mixture of liquid and vapor to that of a superheated vapor. At point B the total heat of the ammonia has risen to 618.9 B.t.u.

The next part of the cycle is that of the compression of the vapor. It is shown following a theoretical constant entropy line C-D. During this compression the heat of mechanical work is added to the ammonia and the total heat reaches a value of 720.6 B.t.u. at a pressure of 154.5 lb. gage. The total heat added by the



AMMONIA PERFORMANCE CHART WITH STANDARD TON CYCLE IN OUTLINE

compressor is the difference in B.t.u. value at C and at D. This value is the heat added by compression to each pound of ammonia compressed.

From D to A there is represented the negative work of cooling done by the condenser. As shown, the heat removed by the condenser is the sum of the heat added in the cooler or evaporator and the heat added by compression. The heat equal to that taken up in the cooler is recovered in the cycle in the useful work of cooling the brine or cooling room, but the heat of compression must be completely lost to the condenser and in the cycle unless some auxiliary heat exchanger is included in the system.

This completes the cycle and the ammonia is again ready to pass through the expansion valve on its next cycle. To simplify the interpretation of the diagram on the chart, the values for only standard conditions have been traced out. For other than standard values, the same application can be made as with standard values. By this method, the complete performance of the cooler, compressor and condenser can be determined and compared with the ideal or standard.

To trace a cycle for conditions other than standard, assume a receiver temperature of 60 deg. F. at 140 lb. gage pressure, and an inlet pressure at the compressor of 30 lb. gage and 50 deg. F. temperature.

The point corresponding to A of the standard diagram will now be at the intersection of the 140 lb. gage pressure line and the 60 deg. F. liquid temperature line. Point B will be on the 30 lb., gage, line at the same heat value as that of the 60 deg. F. liquid line at 140 lb. pressure. Point C will be at the intersection of the 30 lb. pressure line and the superheated vapor temperature line of 50 deg. F. This intersection is at an entropy of 1.341.

Compression will now take place, and if the compression is a constant entropy change of pressure the entropy will remain constant and will cross the 140 lb., gage, line when the total heat equals 717.5 B.t.u.

From tracing this performance, it will be seen that the heat value at B is 109.1 B.t.u. while at C it is 636.6 B.t.u. The refrigeration effect will be 636.6 — 109.1 or 527.5 B.t.u. Since standard refrigeration effect is 490.3 B.t.u. the assumed performance is above standard and represents conditions similar to those experienced in cold weather.

The heat that must be removed by the condenser is the difference between 717.5 and 109.1 or 608.4 B.t.u. for every pound of ammonia pumped.

This chart, similar in some respects to the Bureau of Standards Chart, was developed by Leo Holdredge, a graduate student in Mechanical Engineering at the University of Tennessee, for the purpose of giving the essential values of the refrigeration cycle on a convenient scale for interpolation. The central part of the diagram, unessential to the refrigerating engineer in the reading of performance values, has been removed.

Applying the chart to Standard Ton Conditions in determining horsepower required:

To change one horsepower into heat units, it is necessary to divide 33,000 by 778 since 778 ft. lb. equals one B.t.u. 33,000 divided by 778 equals 42.5.

Thus, if we will divide the heat units in B.t.u. required to be supplied by the compressor for each ton of refrigeration by 42.5, the answer will equal the theoretical horsepower required per ton for operating under these conditions.

By equation the theoretical horsepower required for producing a ton of refrigeration will be, then

$$\text{I.H.P.} = M\ ([H_{com.} - H_{evap.}] \div 42.5)$$

Where M = Ammonia required per minute to make one ton of refrigeration, $H_{com.}$ = Total heat of one pound of ammonia at compressor outlet pressure and temperature. $H_{evap.}$ = Total heat of one pound of ammonia at suction pressure and temperature.

Using the chart, we find that for standard conditions $H_{com.} = 720.6$ B.t.u. and $H_{evap.} = 618.7$ B.t.u.

The value of M for standard conditions was found to be 200 divided by 490.3 or .4079 lb.

Then substituting in the formula:

$$\text{I.H.P.} = .4079 \times \frac{720.6 - 618.7}{42.5} = .979 \text{ hp.}$$

Applying the Chart for Power Computations for Conditions Other than Standard; to show the application of power computations using the Performance Chart values, the problem previously used in following through the cycle for conditions other than standard will be used.

In this problem in which we assumed a receiver temperature of 60 deg. F. at 140 lb. gage pressure with an inlet pressure at the compressor 30 lb. gage and 50 deg. F. temperature, $H_{com.}$ would equal 717.5 and $H_{evap.}$ would equal 636.6.

The refrigeration effect was 636.6 — 109.1 or 527.5 B.t.u. M therefore would equal 200 divided by 527.5 or .379 lb. per t.

Then for these conditions other than standard the substitution in the formula would become:

$$\text{I.H.P.} = .379 \frac{717.5 - 636.6}{42.5} = .712 \text{ hp.}$$

Actual Power Requirements at Ammonia Cylinder; the actual power required at the ammonia cylinder will equal the theoretical required input divided by the volumetric efficiency, or

$$\text{Actual Power Required at Ammonia Cylinder} = \frac{\text{Theoretical Input}}{\text{Volumetric Efficiency}}$$

Volumetric efficiency will vary in compressors from .63 to .87 depending upon type of machine, size of compressor, and speed and pressure at which it is operating.

Actual Power Input Requirements of the Driving Unit

Power input in the driving unit, whether it is a motor or engine, will exceed the power required at the ammonia cylinder by an amount equal to the friction and other losses in the driving unit. To determine the total power required it will be necessary to divide the actual power required at the cylinder by the machine efficiency.

Actual power required usually exceeds the theoretical horsepower by 50 per cent. This difference is brought about by the losses in the machine.

Bleeder Turbines in the Chemical Industry

SURVEY OF ONE PLANT SHOWS TWO POINT EXTRACTION TURBINE AND MOTOR GENERATOR SETS GIVE MINIMUM INVESTMENT AND INSTALLATION COSTS. BY C. J. COLLEY*

FOR A NUMBER of years the Monsanto Chemical Works has had a power plant at its East St. Louis Works. The boiler room has four 600-hp. Edgemoor boilers with natural draft Illinois stokers furnishing about 40,000 lb. of steam per hour at 150 lb. pressure for process work. The generating equipment was not suited to the load so electric power was purchased at a

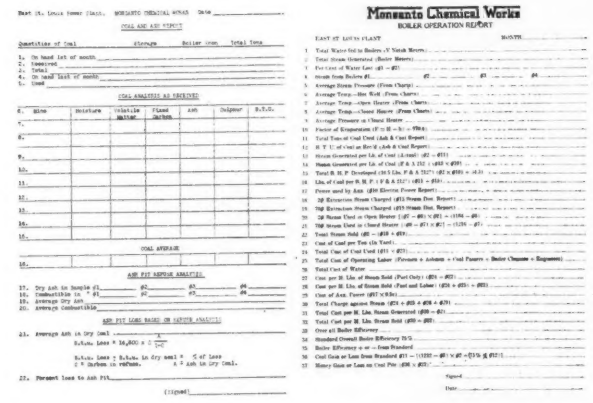


FIG. 1. COMPLETE DATA ON COAL REPORTS, ASHPIT LOSSES AND BOILER ROOM OPERATION ARE KEPT

cost of approximately $2200 per month. The electrical load was rapidly increasing and we were about to start up a chlorine plant that would take about 800 kw., so a study was made to determine whether it would be possible to generate our own power cheaper than we could purchase it.

It should be understood that the Works had a complete operating boiler room, engine or generating equipment space and a partial crew of operating engineers taking care of air compressors, etc., so building cost was eliminated and operating labor cost would be increased but very little.

A preliminary study showed that we could generate power cheaper than it could be purchased. The chlorine cells are grouped in two series so two separate d.c. generating units were needed with a third for spare and, of course, two a.c. generating units, one of them for spare. This combination looked good, but the writer felt that power could be generated still cheaper if the factory process steam pressure could be lowered, so a complete survey was made of all steam-using equipment throughout the plant. This survey disclosed the fact that 95 per cent of the equipment could operate on 70 lb. steam pressure.

Of course a few lines had to be enlarged. This being taken care of, the steam pressure was lowered from 150 lb. to 70 lb., 10 lb. at a time over a period of several weeks. There were of course some complaints from department operators but the writer resorted to the old trick of setting the steam gages to read a higher pressure than they were actually obtaining.

*Efficiency Engineer, Monsanto Chemical Works.

It seems strange but is, nevertheless, true that whenever the steam pressure is lowered in a manufacturing plant, the operators lay all their troubles to low steam pressure.

The plant now being on 70 lb. pressure, the next point was to see how high we could go on boiler pressure. The insurance company was called in and passed the boilers for 225 lb. working pressure. The departments which could not operate on 70 lb. pressure were taken care of by means of steam compressors, that is, ordinary compressors compressing the steam from 70 to the desired steam pressure.

Calculations were then made showing the cost of power by using a straight condensing a.c. turbo-generator with motor generator sets changing approximately 40 per cent of the a.c. power to d.c. for chlorine

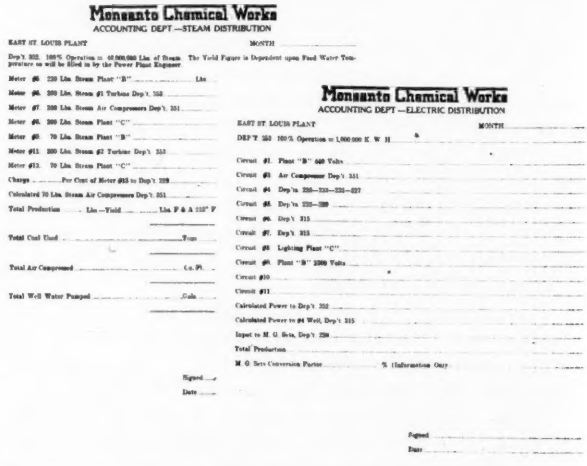


FIG. 3. CHARGES AGAINST THE VARIOUS DEPARTMENTS ARE MADE ACCORDING TO QUANTITIES USED AS SHOWN ON THE ABOVE FORMS

cells. This showed that, despite the conversion loss, power could be generated cheaper by means of one large unit than it could by means of a number of small a.c. and d.c. generating units with their comparatively high steam consumption.

Conditions appeared promising so we proceeded to work up what we called our ideal scheme that had already been worked up in a preliminary fashion. We called upon turbine manufacturers for curves on an 1850-kv.a., 2300-v. turbo generator set designed for 225 lb. initial steam pressure with automatic bleeding devices for bleeding at 70 and 2 lb. pressure, and for 2300-v. motor generator sets designed for leading power factor that would enable us to carry unity power factor on the main generator.

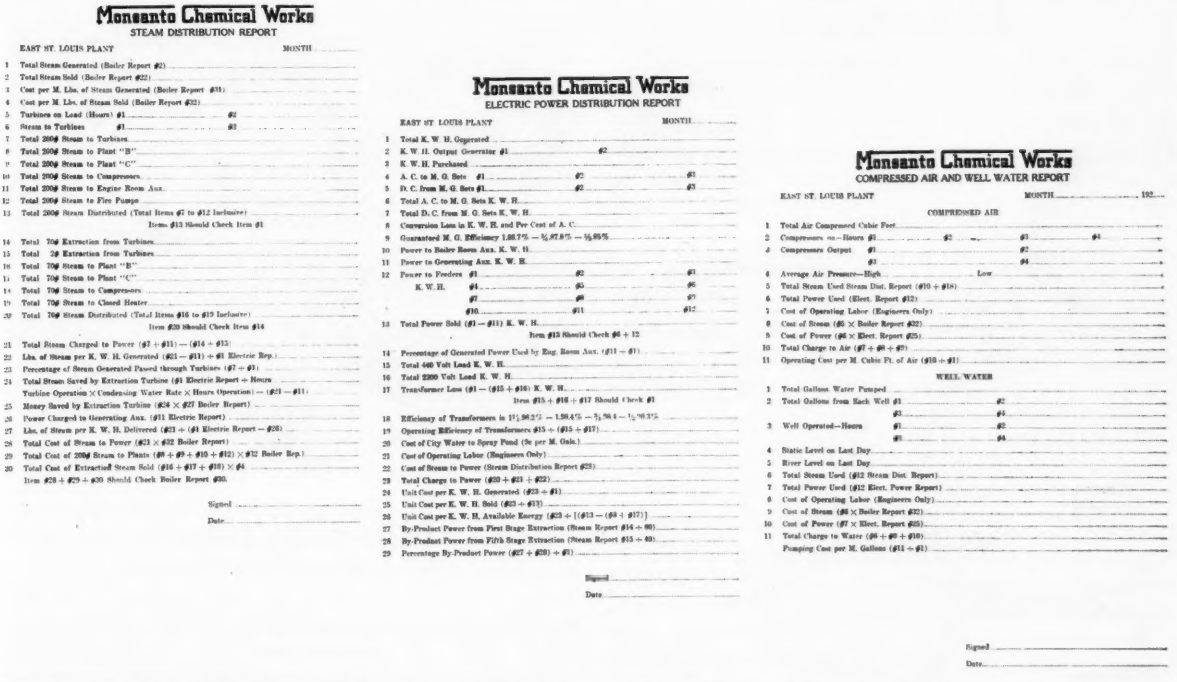
From the data furnished by the manufacturers, we found that, by installing an 1850-kv.a. double bleeder condensing turbo generator and converting about 40 per cent of the power from 2300 v. a.c. to 250 v. d.c.,

furnishing 38,000 lb. of 70 lb. bled steam for factory process, using trap drains and steam drips to heat the boiler feed hot well, then using 2 and 70 lb. bled steam for stage heating of feed water, we could generate power much cheaper than by any other method and, of course, cheaper than it could be purchased. The investment and installation costs were lower than they would have been for a number of small separate units for both a.c. and d.c. The bleeder turbine, a General Electric unit, was installed and is working perfectly.

The turbine has an Elliott double water box surface condenser with spray pond and dual drive condensate and circulating pumps. The exciters are dual drive with the turbine end set for 20 r.p.m. lower than the motor. The turbine end comes into service in case of trouble to the motor or its power supply. The 70 lb.

Condensate is also metered. The operators are all thoroughly familiar with equipment guarantees and are instructed how to make checks. This creates an interest that is lacking in many plants where the chief engineer is the only one supposed to know anything about the manufacturer's guarantees.

Boilers in this plant are all equipped with meters, the coal is handled and weighed by means of a weigh larry, the boiler efficiency is posted every 8 hr., and all boiler room employes are working on a bonus system based on overall boiler efficiency. The minimum is set at 69 per cent for which no bonus is paid but each 1 per cent above this is paid for at an increasing rate. The recent coal strike has upset the boiler room operation so that conclusive results of the bonus system are not available. The indications are, however, that we



Monsanto Chemical Works
STEAM DISTRIBUTION REPORT

EAST ST. LOUIS PLANT MONTH

1	Total Steam Generated (Boiler Report #2)
2	Total Steam Sold (Boiler Report #22)
3	Cost per M. Lbs. of Steam Generated (Boiler Report #31)
4	Cost per M. Lbs. of Steam Sold (Boiler Report #32)
5	Turbines on Load (Hours) #1 #2
6	Steam to Turbines #1 #2
7	Total 205# Steam to Turbines
8	Total 205# Steam to Plant "B"
9	Total 205# Steam to Plant "C"
10	Total 205# Steam to Compressors
11	Total 205# Steam to Engine Room Aux.
12	Total 205# Steam to Fire Pumps
13	Total 205# Steam Distributed (Total Items #7 to #12 Inclusive) Item #13 Should Check Item #1
14	Total 70# Extraction from Turbines
15	Total 2# Extraction from Turbines
16	Total 70# Steam to Plant "B"
17	Total 70# Steam to Plant "C"
18	Total 70# Steam to Compressors
19	Total 70# Steam to Closed Heater
20	Total 70# Steam Distributed (Total Items #16 to #19 Inclusive) Item #20 Should Check Item #14
21	Total Steam Charged to Power (#7 + #11) — (#14 + #15)
22	Lbs. of Steam per K. W. H. Generated (#21 — #11) ÷ #1 Electric Rep.)
23	Percentage of Steam Generated Passed through Turbines (#7 ÷ #2)
24	Total Steam Saved by Extraction Turbine (#1 Electric Report ÷ Hours Turbine Operation) × (Condensing Water Rate × Hours Operation) — (#23 — #11)
25	Money Saved by Extraction Turbine (#24 × #27 Boiler Report)
26	Power Charged to Generating Aux. (#11 Electric Report)
27	Lbs. of Steam per K. W. H. Delivered (#23 ÷ #1 Electric Report — #26)
28	Total Cost of Steam to Power (#23 × #32 Boiler Report)
29	Total Cost of 205# Steam to Plants (#8 + #9 + #10 + #12) × #32 Boiler Rep.)
30	Total Cost of Extracted Steam Sold (#16 + #17 + #18) × #4 Item #28 + #29 + #30 Should Check Boiler Report #30.

Signed .....
Date .....

Monsanto Chemical Works
ELECTRIC POWER DISTRIBUTION REPORT

EAST ST. LOUIS PLANT MONTH

1	Total K. W. H. Generated
2	K. W. H. Output Generator #1 #2
3	K. W. H. Purchased
4	A. C. to M. G. Sets #1 #2 #3
5	D. C. from M. G. Sets #1 #2 #3
6	Total A. C. to M. G. Sets K. W. H.
7	Total D. C. from M. G. Sets K. W. H.
8	Conversion Loss in K. W. H. and Per Cent of A. C.
9	Guaranteed M. G. Efficiency 1.33.7% — ½ of 1.5% — ½ of 5%
10	Power to Boiler Room Aux. K. W. H.
11	Power to Generating Aux. K. W. H.
12	Power to Feeders #1 #2 #3 K. W. H. #4 #5 #6 #7 #8 #9 #10 #11 #12
13	Total Power Sold (#1 — #11) K. W. H. Item #13 Should Check #6 + 12
14	Percentage of Generated Power Used by Eng. Room Aux. (#11 ÷ #1)
15	Total 440 Volt Load K. W. H.
16	Total 2300 Volt Load K. W. H.
17	Transformer Loss (#1 — (#15 + #16) K. W. H. Item #15 + #16 + #17 Should Check #1
18	Efficiency of Transformers in 1½ of 2.5% — 1.59.4% — ½ of 5% — 98.4 — ½ of 0.5%
19	Operating Efficiency of Transformers (#15 + (#15 + #17)
20	Cost of City Water to Spray Pond (3c per M. Gals.)
21	Cost of Operating Labor (Engineers Only)
22	Cost of Steam to Power (Steam Distribution Report #29)
23	Total Charge to Power (#20 + #21 + #22)
24	Unit Cost per K. W. H. Generated (#23 ÷ #1)
25	Unit Cost per K. W. H. Sold (#23 ÷ #13)
26	Unit Cost per K. W. H. Available Energy (#23 ÷ [(#13 — (#3 + #17)]
27	By-Product Power from First Stage Extraction (Steam Report #14 ÷ 80)
28	By-Product Power from Fifth Stage Extraction (Steam Report #15 ÷ 80)
29	Percentage By-Product Power (#27 ÷ #28) ÷ #1)

Signed .....
Date .....

Monsanto Chemical Works
COMPRESSED AIR AND WELL WATER REPORT

EAST ST. LOUIS PLANT MONTH ..... 192...

COMPRESSED AIR

1	Total Air Compressed Cubic Feet
2	Compressors on—Hours #1 #2 #3 #4
3	Compressors Output #1 #2 #3 #4
4	Average Air Pressure—High Low
5	Total Steam Used Steam Dist. Report (#10 + #16)
6	Total Power Used (Elect. Report #12)
7	Cost of Operating Labor (Engineers Only)
8	Cost of Steam (#5 × Boiler Report #32)
9	Cost of Power (#6 × Elect. Report #25)
10	Total Charge to Air (#7 + #8 + #9)
11	Operating Cost per M. Cubic Ft. of Air (#10 ÷ #1)

WELL WATER

1	Total Gallons Water Pumped
2	Total Gallons from Each Well #1 #2 #3 #4
3	Well Operated—Hours #1 #2 #3 #4
4	Static Level on Last Day
5	River Level on Last Day
6	Total Steam Used (#12 Steam Dist. Report)
7	Total Power Used (#12 Elect. Power Report)
8	Cost of Operating Labor (Engineers Only)
9	Cost of Steam (#6 × Boiler Report #32)
10	Cost of Power (#7 × Elect. Report #25)
11	Total Charge to Water (#8 + #9 + #10) Pumping Cost per M. Gallons (#11 ÷ #1)

Signed .....
Date .....

FIG. 2. SUMMARIZED DISTRIBUTION REPORTS FOR STEAM, ELECTRIC POWER, COMPRESSED AIR AND WELL WATER ARE MADE UP EACH MONTH

bleeder pressure never varies more than 4 lb. The steam consumption per kw-hr., after moisture corrections have been made, is lower than we could expect by any other method of power generation for this size plant. At present we are getting approximately 25 to 30 per cent of our electric power as a by-product of process and heater steam.

All steam to and from the turbine is measured by means of flow meters which are checked once a month. All traps discharge to the boiler feed hot well and charts are furnished the operators showing the effect of a leaky steam trap, that is, it shows what power this leaking steam would have generated had it passed through the turbines. The guaranteed turbine steam rates with different extraction and power loads are also shown on large charts so that the operators can check the turbine performance at any time. This is checked and reported once a shift.

can expect an efficiency well over 70 per cent for which all boiler room employes will receive a fair bonus.

Regarding the operation and cost accounting of this plant, we have done everything possible to create a personal interest and to prevent the old game of "passing the buck." Engineers and oilers are responsible for everything during their shift although the engine room equipment is split up so that each man has certain equipment to which he must pay particular attention, for instance, all the steam meters in the plant are taken care of by one of the shift engineers. No one else touches them, other than to change the charts. This same system is carried through with electrical instruments and switching equipment, also oil and water testing and conditioning. The oilers have certain sections upon which they can exert extra cleaning efforts. The coal or ash men also have certain sections of the boiler room of which to take care. This method of operation

prevents the men from holding back on jobs they don't care so much about or of one man doing a job and the other fellow undoing it.

The boiler and engine room operating costs are kept separately. The total cost per thousand pounds of steam is calculated and sold to the engine room at that rate; the engine room then charges the factory for the steam bled. There are, of course, corrections for pressure and moisture. The steam that is bled back to the heaters is charged back to the boiler room. With this method of accounting, the monthly reports become a heat and money balance sheet; all the money spent and steam generated in the boiler room goes to the engine room where it must be accounted for.

Speed Measurements Should Be Accurate

MANY TYPES OF SPEED INDICATORS AND RECORDERS SIMPLIFY THE SPEED MEASUREMENT PROBLEM

AS THE SPEED of a machine always bears an important relation to its operation or output, the measurement of this quantity assumes considerable importance, especially in view of the fact that many

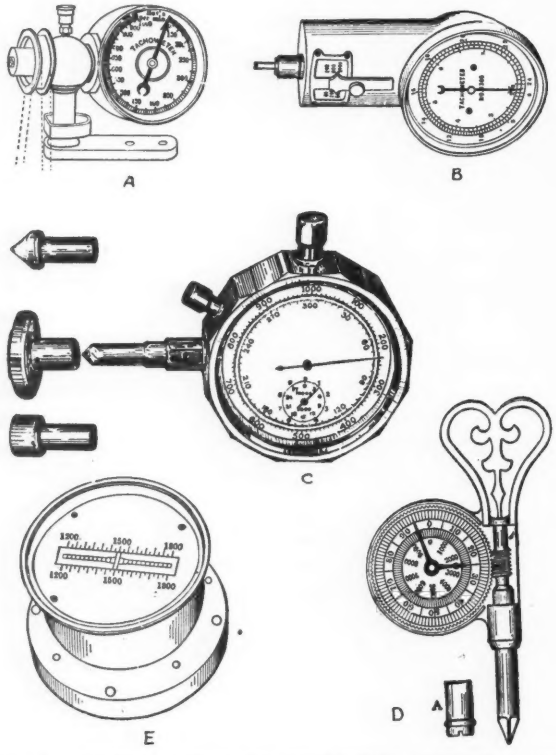


FIG. 1. SEVERAL TYPES OF REVOLUTION COUNTERS AND SPEED INDICATORS IN COMMON USE

auxiliaries around the power house are now equipped with variable speed drives primarily to give greater flexibility in operation and increased economy.

For tests or for an occasional means of checking the speed of centrifugal machines, a hand revolution counter, such as shown in Fig. 1-d, is the cheapest and simplest. This counter consists of a small dial geared to a shaft, and held in contact with the shaft whose speed it is desired to measure. The total revolutions over a certain period of time are found, and from this the speed can be calculated. As it is necessary to use a watch in conjunction with a counter of this kind, and observe them both at the same time, a combined revolution counter and watch as shown in Fig. 1-c has been developed.

This instrument measures the total revolutions over a certain fixed period of time and automatically gives the average speed over that period. The shaft can be kept in contact with the machine and the readings repeated several times in order to get a good average. Another type of instrument based on the centrifugal principle is shown in Fig. 1-a and 1-b. The hand instrument is particularly convenient for testing work, giving

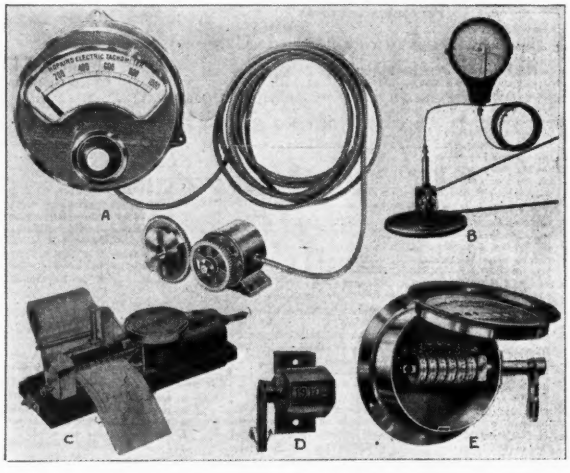


FIG. 2. INSTRUMENTS CAN BE OBTAINED TO GIVE EITHER THE TOTAL REVOLUTIONS OVER A PERIOD OF TIME OR TO RECORD THE SPEED CONTINUOUSLY

an indication of the speed direct without relation to the time. With the portable hand type, three gear ratios are usually used so that it is possible to get a reasonable scale deflection with practically any speed up to 6000 r.p.m. The form in Fig. 1 is provided for permanent attachment or for longer tests.

Practically all engines and many reciprocating pumps are equipped with counters such as shown in Fig. 2-e. By reading a counter of this kind periodically, the displacement or average speed of a machine during a certain period can be calculated. This instrument is particularly valuable for permanent records showing the operation of each machine. A smaller form of the same type of counter is shown in Fig. 2-d. For turbines the vibrating reed tachometer as shown in Fig. 1-e, is used almost universally. It is adaptable not only to turbines, but all kinds of centrifugal machines. Various lengths of reeds vibrating at different frequencies are used. The particular one shown in the illustration is indicating a speed of 1600 r.p.m.

Electric tachometers such as shown in Fig. 2-a are on the market and are particularly suitable for extremely high speeds. These consist essentially of a small magneto or dynamo geared to the machine and con-

nected electrically with an electrical indicating instrument. Figure 2-b is a pneumatic tachometer, in effect a small rotary vacuum pump. The speed with which this pump operates determines the vacuum in a tube and the recording mechanism consists of a recording vacuum gage. Another type, known as the fluid tachometer, has been developed, but is not in general use. It is essentially a small centrifugal pump discharging into a vertical glass discharge tube. The height of the liquid indicates the speed of the pump. The column varies approximately as the speed of the pump impeller which is fastened directly or geared to the machine. Graduations near the bottom of the scale are close together and this type of tachometer is not suitable for speeds below 300 or 400 r.p.m.

Because of the importance of the speed relation to the operation of various pieces of equipment, it is often desirable to have not only an indication of the speed at a particular time, but a complete record of the speed over certain periods of the day. This can be accomplished by a number of recording speed gages of which several are illustrated in Fig. 2. Any of the electric, pneumatic or fluid tachometers can be equipped with recording mechanisms, with little or no trouble, depending a great deal upon the measurements of electricity or pressure for which many reliable recording gages have been developed. Figure 2-c illustrates the application of a recorder to a centrifugal type tachometer of the general type shown in Fig. 1-b. It may be attached permanently, or held in place for a desired length of time by hand, although it is essentially a test instrument designed to cover a wide range of speed by means of gear shift devices. For permanent attachment, one of the other types will probably be found more advisable.

Floating Island

NO THIS isn't the dessert with which our mothers used to tempt our appetites after a hard day of fishing or baseball. It's the latest development in our naval equipment.

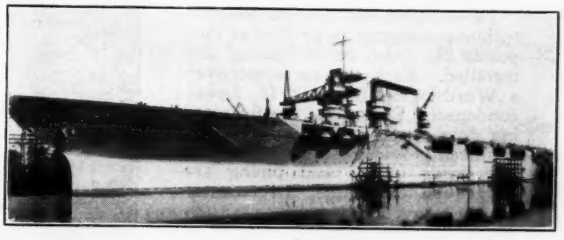
Modern fleets must have air planes for scouting. They must go along with the fleet and must be able to take off and to return regardless of weather. This a hydro-plane cannot do in the open ocean; so a floating island must be taken along for a landing field.

That's where the Saratoga, placed in commission in November, comes in; also the Lexington which is now building. Originally, she was intended for a battle cruiser but when the limitation of naval armament was agreed upon, she was converted to an airplane carrier, a floating garage to carry 83 planes below deck, with deck space 888 by 106 ft., where a large part of the planes can be parked and still leave room for taking off and alighting. Special provision is made for launching sea planes and for stopping airplanes when alighting.

Main turbines of 180,000 hp. built by the General Electric Co. will give a cruising speed of 38 mi. per hr., a capacity sufficient to supply the electric needs of the city of Philadelphia. Four 35,200-kw. turbine-generator sets supply current to 8 22,500-hp. motors placed in pairs to drive 4 propeller shafts at 317 r.p.m. Steam is supplied by 16 oil-fired boilers.

Auxiliary power for steering, ventilation, hoisting, lighting, radio and machine shop is furnished by 6 750-kw. direct-current turbine-generator sets, all equipment, even for cooking and refrigeration being electrically driven.

Really the Saratoga is a floating city. Hangar and elevators; quarters for 2034 men and officers; machine, carpenter, sheet metal, plumbing and fabric shops; testing laboratory and supply department; butcher shop, bakery, tailor shop, mess rooms, canteen, stores and even a soda fountain are among the provisions for serving the population. Radio, of course; several transmitters which can send and receive without mutual interference, the main set being the most powerful on any



U. S. S. SARATOGA

vessel in the navy except the Lexington, which has like equipment.

As armament, eight 8-in. long range rifles and 12 anti-aircraft guns will ward off destroyers and enemy planes, but the Saratoga is not a fighting ship and is provided only with defensive equipment.

Packing for Hydraulic Machines

VARIOUS FORMS OF PACKING for hydraulic machines are discussed in a recent report of the N. E. L. A. Hydraulic Power Committee. Experiences of many operating companies are summarized and from these records and a study of the physical properties of packings, the following conclusions are drawn:

Flax packing is the most generally used. As generally used, it forms a satisfactory hydraulic seal.

Long fiber asbestos packing, impregnated with a graphite lubricant, has given good results with long life in one large, low-head plant.

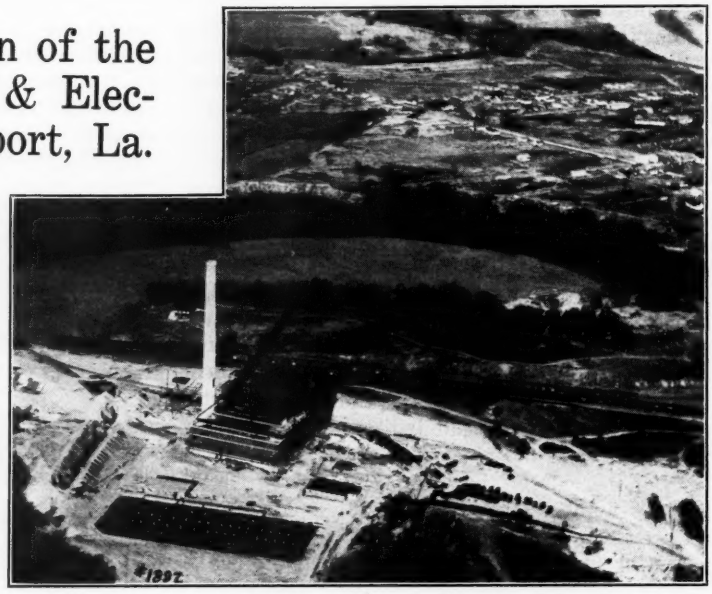
Hemp packing may be used if strict attention is given to impregnation and lubrication. Hemp packing has a shorter life than flax packing, for which reason it is not generally used on hydraulic units.

Cotton packing has greater absorbing properties for lubrication than flax or hemp, hence the tendency to cut the shaft is lessened. Cotton packing has not been in use on hydraulic machines a sufficient length of time to determine its average life.

A granulated wood and metal packing, impregnated by boiling processes, is being used quite extensively with satisfactory results. It has a longer life and wears less on the shaft than flax.

Plastic metallic packing is made by several of the leading packing manufacturers. One company reports its use in connection with hydraulic machines. This single report shows a life to date of 5½ yr. with the shaft in good condition.

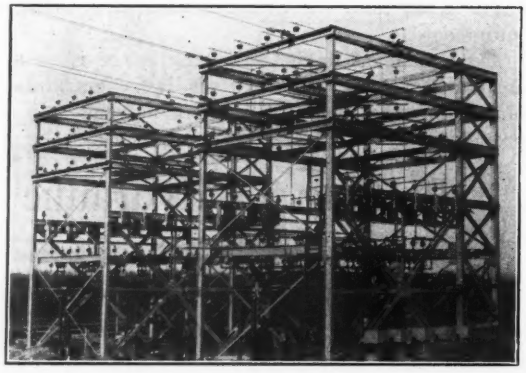
Arsenal Hill Station of the Southwestern Gas & Electric Co. at Shreveport, La.



WITH THE COMPLETION of the Arsenal Hill Station of the Southwestern Gas & Electric Co. of Shreveport, La., an additional 30,000 kw. capacity has been added to the system of this company.

Three 10,000-kw. General Electric turbines, designed to be bled at two points for feed water heating are installed. Each turbine is set over a Worthington 17,500-sq. ft., 2-pass condenser. Because of the fluctuating flow of the river, a spray pond has been provided with the circulating water pumps and piping arranged so that either river water or the spray pond may be used together or separately.

Two 16,800-g.p.m., 32-ft., circulating pumps, driven by 200-hp. motor, are provided at the intake crib and may be used to supply circulating water to any of the units. In addition to these two pumps, two 8400-g.p.m., 45-ft. head pumps driven by 150-hp. motors and two 16,800-g.p.m., 45-ft. head pumps, driven by 300-hp. motors, are provided for use when the spray pond is in service.



Steam is supplied to the turbines at 275 lb. gage, 200 deg. F. superheat, by three 10,820-sq. ft. Heine boilers 18 tubes high and 31 tubes wide and by three 10,800-sq. ft. Springfield boilers 16 tubes high and 38 tubes wide. All boilers are equipped with Elesco superheaters.

Both oil and gas are used as fuel, gas being taken directly from the mains of the company, while oil storage is provided by a 10,000-bbl. tank. Webster combination oil and gas burners are used, the change-over from gas to oil or oil to gas being made at the operator's desire in a very short time. The station was designed by Sargent & Lundy, and built by Glassell - Wilson Co.

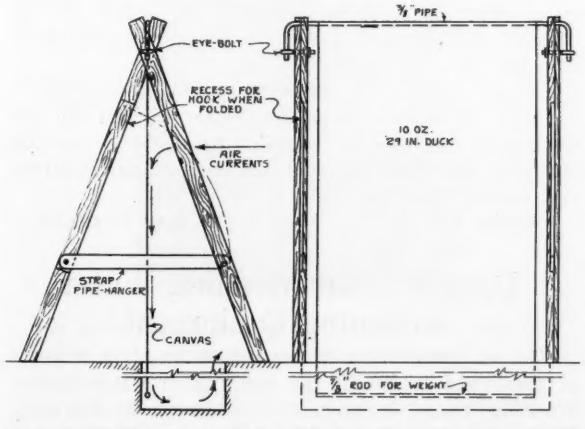
Steam Manhole Ventilation

HERE IS A sketch of a steam manhole ventilator that we have used for some time, in connection with work on a district heating system.

Material needed to build the ventilator is as follows:

4 1 by 1½-in. pine sticks about 3 ft. long.
1 ⅜-in. pipe about 4 ft. long.
2 ¼-in. eye bolts 2 in. long.
2 pcs. No. 3 strap pipe hanger.
4 No. 12 wood screws 1 in. long (round head).
1 ⅞ or 1-in. rod about 2 ft. long.
½ pint red paint.
Enough 10-oz. canvas to reach bottom of deepest manhole. Total cost is saved in time of getting into one hot hole.

The idea is to have something easily carried that will fit in any depth manhole. The two end pieces or



CANVAS SUPPORTED ON PORTABLE FRAME DEFLECTS BREEZE TO VENTILATE MANHOLE

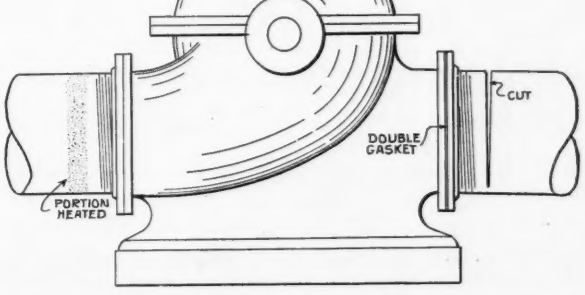
legs of which one is shown, are made out of 1 by 1½-in. pine with eye bolt through at the crossover at the top, with the eye just large enough for the bent ends of the ⅜-in. pipe to go through. The canvas is sewed to the pipe and carried rolled on the pipe; for use it is unrolled to reach within about a foot of the bottom of the manhole. The legs are carried folded and for use are pulled apart at the bottom and the pipe strap hooked across on the screw of the other leg. Then the pipe is laid across the V on top and down through the eyes, is centered on the hole and turned so the breeze hits the canvas and turns down into the hole, driving the steam and hot air up and out on the other side.

With just a fair breeze blowing it will ventilate a hot manhole so a man can go into it in about 15 min. If painted red, it also serves as a barricade over hole while open.

Salt Lake City, Utah. E. G. KNAPP.

Misalinement Corrected by Heating and Welding

UNSUPPORTED heavy piping frequently has an effect upon a machine that is not always realized and often



STRAINS, WHICH CAUSED MISALINEMENT OF PUMP, REMOVED BY HEAT TREATMENT

strains result that force a machine out of line and affect its operation.

After properly setting and lining a 12-in. circulating pump, the pipe connections were made without providing an expansion joint. After the joints were tightened, the bearings heated and the coupling became so noisy that it was necessary to shut down and investigate. The coupling was found $\frac{1}{16}$ in. out of line in two directions. Cap-screws at the base and the flanges were loosened, and the pump forced back in line, after which all were retightened and the dowel pins replaced by larger ones. This did not improve the operation, as the same strain forced the pump out of line as before. The piping was next investigated.

In loosening both flanges, the pump returned to its original correct place, but the pipe swung out making the space at the flange nearly ¼ in. wider at one side than the other. The flanges were threaded on the pipes and it was not advisable to change them so the nipple near the pump was cut almost all around with a torch, but leaving about ½ in. near the bottom to hold. The flange was then tightened to the pump and the opening welded in place. This took most of the strain out, but when it cooled off and one flange was loosened, it showed

that a difference of 1/64 in. still existed. This difference was corrected by placing a double gasket between the flanges.

The other pipe, which had a smaller strain, was heated to bright redness a couple of inches wide all around at about a foot from the flange and this corrected the misalinement at this place.

In finishing the tightening of the flanges, the coupling was carefully checked up, because it was found that tightening more on one side than the other would strain the pump frame out of line.

Clarkdale, Ariz. CHAS. LABBE.

Pilot Lights Prevent Destruction of Apparatus

PILOT lights, judiciously used, can be of great help to the operating engineer. Figure 1 shows a schematic diagram of the wiring system of a remote control naphtha distributing system. The naphtha tank is buried underground, beneath the electric motor and pump. The suction pipe leads from the tank to the pump. The delivery pipe is then run from the pump, underground, to the various buildings; where automatic remote con-

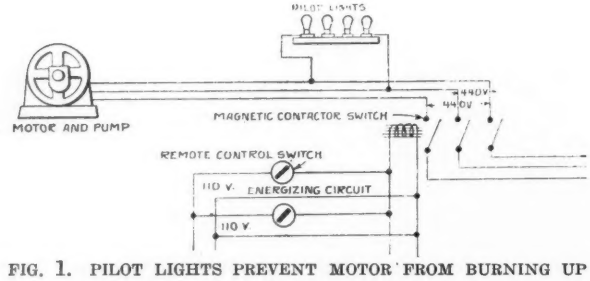


FIG. 1. PILOT LIGHTS PREVENT MOTOR FROM BURNING UP

trol faucets are located. The remote control faucets are combined switches and faucets; that is, opening the faucet closes the electric switch and closing the faucet opens the switch.

When the faucet is opened, the switch is closed on the 110-v. line; this in turn energizes a magnetic contactor switch, which closes the 440-v., 3-phase current on the pump motor, starting the motor and pump, at the same time causing the naphtha to be delivered to the open faucet.

Unfortunately these valves, like much of our automatic equipment, occasionally go wrong. In this case the electric switch sometimes sticks and stays open. This is a very serious matter because the small naphtha pump motor was not chosen to do continuous duty. When run any length of time it overheats. If not noticed in time there is a possibility of the motor burning up. This trouble happening so near the naphtha pump is liable to result disastrously. To reduce this hazard the four red, 110-v. pilot lights are placed in direct line of view of the operating engineer. The engineer can tell, by watching the lamps, whether the faucets are working right or not.

Another worth while pilot light is shown in Fig. 2. A return tilt trap was installed in the sub-basement shown, in order to save about 2000 lb. of condensate an hour that originally went to the sewer. This water was delivered to the pump room through an overhead pipe that ran outside about a distance of 60 ft. Although this pipe was insulated, the condensate in it froze occasionally. In case something went wrong with the trap, the water from the upper floors would fill up the trap, trip it, and then continue to fill the discharge pipe until the water rose to the level of the overhead outside pipe. Having cooled off considerably by this time, it did not take long, in severe weather, to freeze up the delivery line. In order to determine how the trap was functioning, the pilot light shown was installed at the engineer's desk. In case the red light burns continuously, the engineer or watchman knows that the trap

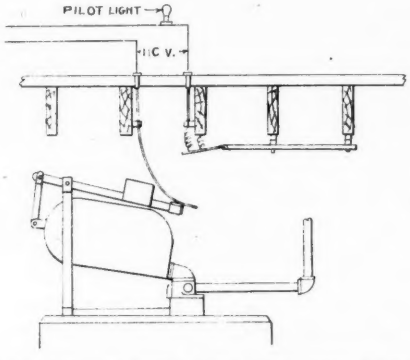


FIG. 2. PILOT LIGHT PREVENTS PIPE LINE FROM FREEZING UP

is not delivering the condensate as it should and can turn the condensate to the sewer, until such time as the trap has been repaired.

Insulated from and attached to the balance lever of the tilt trap is a copper plate contact. When the trap discharges, the balance lever flies up and makes contact with the upper copper plate, completing the circuit and causing the pilot light to burn.

Moline, Ill. ROBERT ALTHAUS.

Danger of Overloading Water Softening Equipment

TO BE EFFECTIVE a water softening plant must be of ample size to handle the quantity of water desired. Working beyond its capacity is dangerous as there may be insufficient time for the necessary reactions to take place in the softener, with the result that some of the chemicals are carried into the boiler. In a London works, an explosion occurred in a water-tube boiler; one of the tubes was pulled out of the back header while carrying a pressure of 195 lb. per sq. in. On examination, the tube which had failed was found to be choked for a considerable part of its length with a soft limey deposit, while some of the adjacent tubes were getting to be in a like condition.

For some time prior to the explosion the softening plant had frequently been worked beyond its capacity, this had not allowed sufficient time for the deposit in the water to settle in the tank. Lime which was used in the softener was carried into the boiler and this, with the other natural deposit formed, had choked the tubes. This shows not only the danger of overworking a softening plant, but also the necessity of frequent blow-

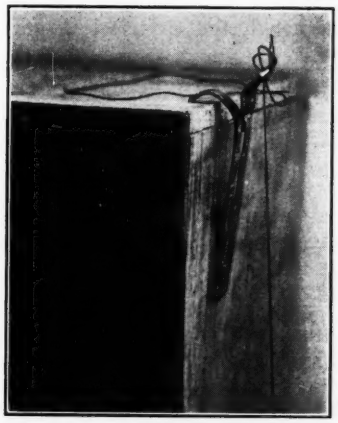
ing down and cleaning of the tubes and drums. Such cleaning in this case had not been done for nine months.

Overloading the boiler may result in the water being drawn from the softener before reactions are completed, this may lead to priming and the deposits in the water carried over with the steam may act on the cylinder lubricant and in certain cases render the lubrication quite ineffective. This is more particularly the case where caustic soda is used as a reagent. Caustic soda is converted to common soda by its reaction with carbonates in the water, some of this is decomposed by any sulphates present in the water, but a large amount remains dissolved, and if through this the boiler water becomes too highly alkaline, there may be trouble with the cylinder lubrication of the engines served with this steam.

Brentford, England. W. E. WARNER.

"Sky-Hook" Supports Plumb Bob String

ONE OF THE handiest things I ever kept with the plumb bob is an old ¾-in. hose clamp illustrated. The closing hook is bent backwards through the slot made originally in punching it out. The point of the



OLD HOSE CLAMP MAKES CONVENIENT AND RELIABLE SUPPORT FOR PLUMB BOB STRING

hook and the bottom of the clamp strip are filed flat and sharpened a bit. No nail is necessary to suspend the bob in many places and the hook serves admirably where it cannot conveniently be tied. The lower end can be forced into cracks in wood or between brick. This device saves many a step in looking for some means of securing this end of the line.

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

Local Deposit of Mud Avoided by Use of Mud Guard

LOCAL DEPOSIT of mud upon the fire sheet of a boiler, which so often results in bagging, may be overcome by the use of a baffle if frequent washing does not suffice.

If the boiler has a manhole below the tubes, such a baffle may be made of three or more pieces of sheet steel about ¼ in. thick and as wide as will pass into the boiler through the manhole. The pieces should be long enough to permit the ends to rest on the shell when placed crosswise; the strip forming a chord, the middle of which is a few inches above the lower portion of the fire sheet where most of the mud usually deposits. Three of these pieces should be fitted with a couple of cross cleats.

This baffle prevents the vertical movement of the water which otherwise would be caused by the great heat below the fire sheet. The rising water strikes the baffle and is deflected toward the ends of the boiler thus preventing the drawing in of mud deposits from all directions.

If there is no manhole below the tubes, strips of steel such as discarded wagon wheel tires or 5 or 6-in. bar steel can be passed in through a hand hole. These pieces, sufficient in quantity to make up the desired width, should be placed side by side. Holes should have been drilled in the middle of each strip so that they may be bolted to cross strips in order to tie them together.

Indianapolis, Ind. JAMES F. HOBART.

Piston Rods Repaired by Turning

IN OVER-HAULING a fire pump, in one plant where I worked, it was discovered that there were no new piston rods for it. The old ones were scored so badly that they could not be assembled so it was decided to turn them down until they were smooth. If turned down

MAKES POSSIBLE CONTINUED USE OF SCORED PISTON ROD

the full length the rod would be too small to hold the piston, crosshead and plunger so we finally turned them down where they ran through the stuffing-box and in that way left the rod full size at the piston, crosshead and plunger ends. Then we bored out the stuffing-box gland and made split brass bushings to fit it and split flat bushings for the bottom of the gland.

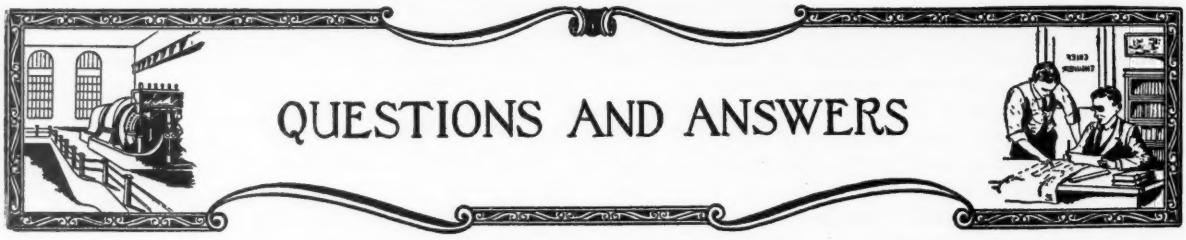
Some persons might say that the turning down would weaken the rods and reduce the capacity of the pump, but in this case it worked fine as the pump was used to float on the line. These turned down rods were used for a long time when they were replaced by rods of full size.

Snoqualmie Falls, Wash. J. W. BEST.

Benson Boiler Operates Successfully

IN THE article printed in your issue of July 1, 1927, page 740, under the title given above, we have discovered a few inaccuracies which we beg to have corrected. In the first paragraph in the sentence "the second, that priming will result at high pressure if more than 125 cu. ft. of steam are disengaged per hour per square foot of surface," it should read 1250 cu. ft. instead of 125 cu. ft. The sentence—"and turned into steam with the slightest decrease of pressure"—causes the impression that the formation of steam is started with a small decrease in pressure. This is not correct; more correctly the water passes into the steam condition when it has reached the critical pressure or above, at a temperature of 374 deg. C. (705.2 deg. F.) without a drop in pressure being necessary for this.

Berlin, Germany. SIEMENS-SCHUCKERTWERKE.



Parallel Operation of 2 and 3-Wire Generating Sets

WILL YOU kindly furnish me with a diagram showing the proper method of connecting two three-wire generating sets and one two-wire generator in parallel?

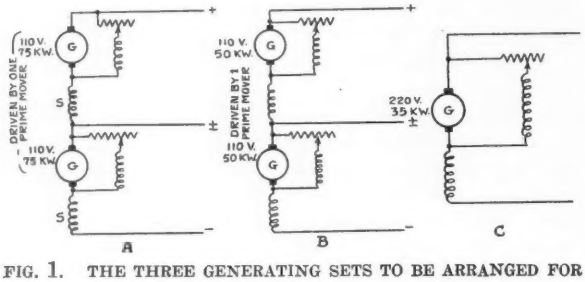


FIG. 1. THE THREE GENERATING SETS TO BE ARRANGED FOR PARALLEL OPERATION

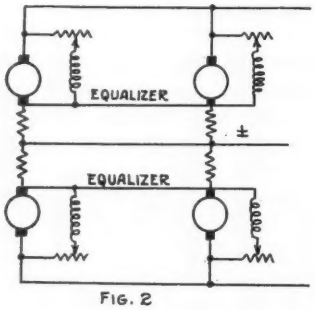


FIG. 2

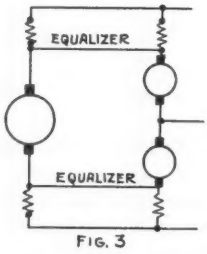


FIG. 3

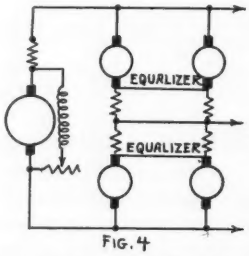


FIG. 4

FIG. 2. CONNECTIONS FOR PARALLELING TWO 3-WIRE SETS

FIG. 3. CONNECTIONS FOR PARALLELING A 2-WIRE GENERATOR WITH A 3-WIRE SET

FIG. 4. PARALLEL CONNECTIONS FOR 2 BALANCER SETS AND A 2-WIRE GENERATOR

Details of the connections of each of these sets are shown in Fig. 1 at A, B and C. I can connect the two three-wire sets without difficulty but I have had considerable argument as to how the two-wire unit is to be connected for parallel operation with the two three-wire units. How should the equalizer be connected? The three sets are to be connected so that any one can be operated alone or any two or all three run in parallel.

Chicago, Ill. C. G. G.

A. In order to show the various steps involved in solving this problem, consider first the connecting of sets A and B in parallel. This is done as shown in Fig. 2 by merely adding the equalizers. If, however, it is desired to connect one of the three-wire sets in parallel with a single two-wire machine it is necessary to split the series field of the latter into halves. This can be done by putting all the north poles on one circuit and all the south poles on the other circuit. A double equalizer is used, the connections being as shown in Fig. 3. This, however, must not be confused with a balancer set such as is commonly used on 3-wire systems, for, although the electrical arrangement is the same, in the case in question, it is assumed that each of the two machines in series constituting a set, is being driven mechanically as generators, independently of the single generator.

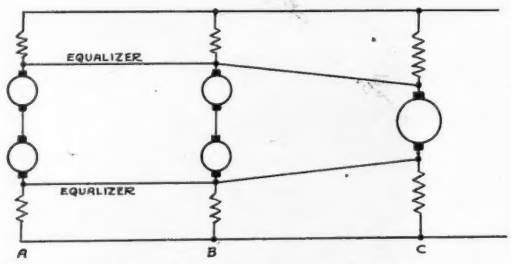


FIG. 5. CONNECTIONS FOR PARALLEL OPERATION OF TWO 3-WIRE GENERATOR SETS AND A 2-WIRE GENERATOR

When two balancer sets are required to operate in parallel, the connections are as shown in Fig. 4. In this case no equalizer connection is necessary between the balancer sets and the main generator.

From a consideration of these various cases, it is apparent that to operate all three sets A, B and C in Fig. 1, in parallel, the connections should be as in Fig. 5. The series fields of the two-wire generator are divided, thus furnishing two points for the connection of equalizers. In all of the diagrams showing the solution of this problem, the shunt fields of the compound generators have been omitted for the sake of simplicity.

Heater and Boiler Connections

YOUR ANSWERS to the following questions will be appreciated:

1. Could two hot-water service heaters be served by one temperature regulating valve if the valve is large enough?

2. On the blowoff lines of our water-tube boiler is a common cock next to the boiler with a blowoff cock on the outside. Is this correct? Wouldn't it be safer and better to have a screw stem valve on the outside?

I. W. C.

A. Whether or not two heaters may be successfully served by a common temperature regulating valve depends upon the manner of connection. If the heaters are connected in parallel and the regulating valve connected to each through piping of the same length and turns and the discharge piping from the heaters equally balanced, there will be no trouble in regulating both heaters by a single regulating valve in common. But if the heaters are connected up in series, one of them may be expected to become much hotter than the other.

2. Proper blowoff connection requires the use of a cock nearer the boiler in the blowoff line and a blowoff valve just beyond the cock or two valves in series are sometimes used.

Heat Reclaimed from Blowdown

WHAT AMOUNT of steam can be evaporated from boiler blowdown water under 200 lb. gage pressure to steam at 4 lb. gage pressure for steam heating? The total blowdown per day equals 60,000 lb. which is about 10 per cent of boiler feed due to high NaCl concentration. Maximum rate of blowdown is 1000 lb. per minute during periods of blowdown. C. F. B.

A. Temperature at 200 lb. g. or 215 lb. abs. = 388 deg.

Temperature at 4 lb. g. or 19 lb. abs. = 225.2 deg. as taken from steam tables. Heat available in the blowdown for heating feedwater is, then:

$$388 - 225.2 = 162.8 \text{ B.t.u. per lb.}$$

Assuming 12.8 as the required difference in temperature between the blowdown and the steam made from feedwater, we have:

$$162.8 - 12.8 = 150 \text{ B.t.u. theoretically available per lb.}$$

From steam tables we find total heat of steam at 19 lb. abs. = 1155.2.

1155.2 ÷ 150 = approximately 8 lb. blowdown water per lb. steam.

Since the total blowdown per day equals 60,000 lb., we have

60,000 ÷ 8 = 7500 lb. steam evaporated per day.

If you are using the blowdown water for heating makeup water and you employed a continuous blowdown method, the above would be available to you but your statement that the maximum rate of blowdown is 1000 lb. per min. during periods of blowdown indicates that you do not use the continuous method. In this case there would be a loss due to radiation if storage is provided or if makeup water is admitted during the periods of blowdown and a counter current heat interchanger is used. The best effect will be obtained in connection with continuous blowdown.

If you are using the blowdown water for the purpose of heating rooms, it could be admitted to the heating mains from a receiver into which it is discharged during blowdown periods. In this case the amount of blowdown per lb. steam would be

$$1155.2 \div 162.8 = 7.1 \text{ lb.}$$

and the steam available for heating at 4 lb. g. neglecting radiation losses would be

$$60{,}000 \div 7.1 = 8450 \text{ lb.}$$

Allowable Concentration Varies with Type of Boiler

WOULD you please advise the maximum concentration which would be allowable in a horizontal return tubular boiler before the boiler should be cleaned. We have endeavored at all times to keep the total solids less than 300 parts per 100,000 but have no definite information as to whether this is the proper value or not.

TABLE SHOWING AMOUNTS OF DEPOSIT CORRESPONDING WITH DIFFERENT DEGREES OF CONCENTRATION

Grains of solid impurities per gal.	Equivalent parts per million	Sediment deposited in lb. per hr.	Sediment deposited in lb. per 10 hr.
5	8.57	0.257	2.57
10	17.14	0.514	5.14
20	34.28	1.028	10.28
30	51.42	1.542	15.42
40	68.56	2.056	20.56
50	85.71	2.571	25.71
60	102.85	3.085	30.85
70	120	3.6	36.0
80	137.1	4.11	41.1
90	154.3	4.63	46.3
100	171.4	5.14	51.4

What would be the maximum concentration which would begin to give trouble, assuming a steam pressure of 125 lb. and boilers about 25 per cent overloaded?

B. H. U.

A. Amounts of sediment which may collect in a 100-hp. steam boiler evaporating 3000 lb. of water per hr., the water containing different amounts of impurities in solution, provided that no water is blown off, are shown in accompanying table.

Frequency of blowing down and the amount of water discharged at each blowdown varies greatly. The allowable percentage of concentration varies considerably with the type of boiler and the rate at which it is operated. It has been found that the allowable degree of concentration for water tube boilers having horizontal tubes may be 500 gr. per gal. or 8550 parts per million; for those having vertical tubes and for horizontal return tubular boilers, the allowable concentration should be only about half of that for horizontal water tubes, i. e., 250 gr. per gal. or 4275 parts per million. The degree of concentration you are now allowing, i. e., 3000 parts per million is, therefore, within proper limits.

Where deconcentrators and continuous blowdown are employed a maximum concentration as low as 100 parts per million is practiced. If the boiler is operated at higher rates of evaporation the amount of sediment formed and the degree of concentration is proportionally increased. Waste of heat due to frequent blowdown can be much reduced by the use of a heat interchanger.

EDITORIAL COMMENT

The Reactive Component

There have been many and diverse opinions expressed by various authorities as to the basic principles which should govern the production of reactive current. One extreme of thought is that the wattless component is a valuable electrical commodity, costly to produce and transmit and as essential to the operation of many types of apparatus as is the power component. Diametrically opposite is that view which assumes it to be a troublesome but generally unavoidable by-product to be curbed and reduced by rate penalties and restrictive clauses in the power contracts.

Between the two views, the reactive component has been the subject of much argument and discussion often with little or no effect because of a lack of understanding of the term itself. Often the terms reactive component, wattless current and power factor are used loosely and without much knowledge of what these terms really mean. As a matter of fact, there is no such thing as a reactive current—there is only one current, (the line current) in a circuit and this is always in phase with the available or energy electromotive force. The division of current into its components is purely a mathematical operation.

It is with the idea in mind of presenting a thorough treatment of the whole subject of the reactive component that we are publishing in this issue the first of a series of articles on this subject by V. E. Johnson. Mr. Johnson has been a frequent contributor to Power Plant Engineering over a period of many years and as many of the readers know has an unusual faculty of explaining complex electrical phenomena in an understandable manner. His many contributions on the theory and operation of electrical machinery have always been received with a great deal of interest and in presenting this series of articles on the reactive component, we can assure our readers of an exceptional treat.

In his treatment of the subject, Mr. Johnson confines himself principally to the engineering aspects of the problem. After discussing the fundamental relations and the physical causes of phase displacement, commercial apparatus is classified on the basis of its power factor characteristics and in succeeding articles the principles that govern power factor improvement are taken up. Methods of correction and means of measurement will receive considerable attention. Finally, consideration will be given to the economic phases of power factor correction.

Because of the growing importance of wattless current as a factor in rate schedule between power companies and users of power, this series of articles is of timely interest. In writing these articles, Mr. Johnson has made a valuable contribution to electrical literature and we do not hesitate to recommend it to our readers.

Public Utility Bonds as Insurance Investment

Distribution of bond investments among twenty-five of the largest insurance companies of the United States and Canada offers striking testimonial of the growing strength of public utilities. Life insurance companies are among the greatest of American investors, they demand absolute security and a reasonable return on their investment.

Total assets of the twenty-five companies amounted to $11,454,989,088 at the end of 1926. Of this total some $4,693,007,642 consisted of bond investments made up of railroad, government, municipal, public utility, industrial and miscellaneous. Railroads make roughly 50 per cent of the total investment. Since 1921 they have increased from 48.3 per cent to 50.8 per cent. During the same five years industrial and miscellaneous bonds have gradually increased from 1.9 to 38 per cent, while government and municipal bonds have steadily decreased from 42.1 to 25.3 per cent. This decrease in government and municipal bonds has been largely taken up by the increase in public utility bonds, which increased from 7.7 to 20.1 per cent. Most of this occurred since 1923.

Public utilities have rapidly won an enviable place in the daily lives of the American public and it is encouraging to find that their financial and economic status is becoming an important factor in financial and investment centers.

Back to the Amoeba

"Now, why in blazes," growled the grizzled, thick-set man seated at the editor's right in the lecture hall of an engineering society, "why in blazes does this poor goof have to go away back into prehistoric times and begin by telling us all about the amoeba before he can get around to giving us some dope on bearings?" The lecturer's subject was Modern Anti-friction Bearings and he had already used up 15 min. of his time in an exhaustive dissertation on the way in which the Egyptians and other ancient peoples had employed the fundamental principles of the anti-friction bearing. After 15 min. of this, there was still no indication that he was approaching the body of his subject.

"I have sat through a great many lectures," continued the editor's neighbor, growling again, "and I'll bet that in at least two-thirds of them the speaker did this same trick.

"Last week it was a lecture on modern types of hydraulic turbines. Well, the speaker told us all about early types of water wheels, showed lantern slide cross-sections of them and gave some interesting dope on them. But I'll be darned if he didn't get almost to the end of his time before he even mentioned the modern

types of turbines that he was supposed to be lecturing about! Blank the blankety dashed idiot!" (Out of regard for the post-office regulations, we delete the growler's expletives.)

"Then again, not so long ago," the growling continued, as the lecturer on the platform showed no signs of leaving the subject of the bobbed-haired Egyptians and their use of bearings, "I listened to a lecture on steel construction. And I'm a blankety blank son-of-a-gun if that speaker didn't also use up about one-third of his talk attempting to make funny cracks about how the Egyptians built the pyramids on a cost plus basis.

"Another galoot began a speech on tool design by talking for a half hour about how the ancients tempered bronze. Then he said, 'We can do it too, but we don't need to because we now have steel.' Of all the—!"

Here the thick-set man paused long enough to determine that the lecturer had by this time reached roller bearings in the Middle Ages. Then he continued his rumbling. "Why in heck don't these fellows get wise to themselves? All that stuff is in the encyclopedia—we can go look it up if we want to. Huh! His subject is modern anti-friction bearings. Then why doesn't he give us some dope on them that we can't get elsewhere? That's what we came here for, isn't it? Is this a kindergarten or an engineers' meeting?

"Bah! I'll bet he thinks that's an introduction to his paper! Why, I'll bet some blankety blank English professor has taught him that every paper has got to have an introduction!" (The editor, a former English professor, pricked up his ears at this.) "Why don't some professor tell these fellows that an introduction is only supposed to lead up to the main subject, not to change it? Sometimes all you need to do is just give the title of the paper and that's all the introduction you need. But, no! This galoot has to make a real job of it and go back to the amoeba to show how the most elementary form of life employs the principle of the anti-friction bearing. I'll be dod-gasted if I'll listen to it any longer!"

Here the thick-set man arose and stamped out of the lecture hall, still growling under his breath. The editor turned back to the lecturer again, to discover that with only 5 min. more to speak, he had at last reached the use of anti-friction bearings during the Industrial Revolution.

Flood Control and the Power Situation

One of the outstanding events of the past year was the Mississippi valley flood with its appalling loss of life and property. Economically and politically its effects will be felt for years not only in the area directly affected but in the country as a whole.

Many magazine articles have covered the subject from every angle. Some of these articles have been good, some bad. The engineering side has been well covered, in a more or less popular way, by John R. Freeman, a world authority on flood control. He covers the subject from all angles, reforestation, reservoirs, spillways and safety mounds, and points out the progress that has been made with the levee system. There were 712 crevasses in 1882-83-84 when most of the levees were fragmentary and practically all lands behind the levees were flooded. In 1912 there were about 15 crevasses in the main river levees, flooding about 30 per cent of the country dependent on them. In the greater flood of 1913, only about half as many breaks occurred as in the previous year with only one of major consequence. In the great flood of 1922 progress in perfecting the levee system had been such that from Cairo to New Orleans, a distance of 969 miles by river, comprising more than 1500 miles of levee, only one break occurred, flooding less than 1 per cent of the entire area.

Most of the control methods proposed are impractical. Of these popular methods reforestation and a combination of power and reservoir systems are the most prominent. A greater part of the drainage area of large rainfall not now forest covered and upon which forests would grow are far more valuable in farms than in forests. C. L. Potter, Chairman of the Mississippi River Commission, in another article pointed out that the runoff now is considerably less than it was in the period before deforestation commenced.

Recently, at Madison, Wis., Daniel W. Mead discussed the Mississippi River problem with reference to flood prevention and water power service. This is no doubt the most popular flood relief idea in the public mind.

It is estimated that the Reclamation Reservoirs on the Western tributaries of the Mississippi River reduced the 1927 flood at Cairo on April 17 to 21 by not more than one quarter inch. Impounding reservoirs if properly placed, will certainly reduce floods but there are other factors to be considered and the demands of flood protection, navigation and power are not readily reconciled. He states:

"It is, of course, evident that the smoothing out of flood peaks and the distributing of maximum flows on the smaller rivers of three or four days over three or four times the period would be of some value to water power developments on such streams, but such value would be small and could be estimated only when all local conditions are fully known. My conclusions are:

"1. That in general the uses of reservoirs for flood protection and water power storage are antagonistic, and therefore dangerous and should seldom be attempted.

"2. That, if attempted, the flood protection purpose should never be sacrificed to the water power uses.

"3. That reservoirs for water power purposes have a minor favorable effect on floods, and reservoirs for flood protection purposes have a favorable effect on water powers, but in general such effects are so small as to be almost negligible.

"4. That as regards reservoirs for the flood relief of the lower Mississippi River, if at all feasible, they must be built in the lower valley flood plain itself, as reservoirs at the head waters of the stream would have little effect toward flood relief if any, and would therefore be practically valueless and financially impracticable.

"5. The water powers of the Mississippi Valley can expect little benefit from the necessary work for the flood protection of the lower valley; and the lower Mississippi Valley can expect little special financial assistance from the water power of the valley for benefits that such powers may realize from such flood protective work."

Power Interests Will Gather in Chicago

LEADERS IN DEVELOPMENT, FINANCE, CONSTRUCTION AND OPERATION WILL MEET FEBRUARY 14 TO 17 AT THE COLISEUM AND THE HOTEL STEVENS

PROGRESS comes from study, consideration, investigation, decision and application. It is necessary to keep one's ideas up to date and to know what others are doing so that one may be thoroughly in touch with the best practice. At the Midwest Power Show and the Midwest Power Conference opportunity comes for the discussion of outstanding present and future problems to determine what requirements must be met in the future, for the consideration of the changes which the wide and increased use of power in this country is effecting on society and how rapidly this increased use of power will accelerate as time goes on.

Estimation of future needs and how to meet them is an important part of the power plant engineer's work. He must determine what amount of power is to be supplied and how it can be furnished with the best economy as and where it is wanted. This requires a study of new developments in equipment, exchange of ideas and experiences with other men, investigation of methods of the most up to date and economical plants and the adaptation of the latest and best equipment to one's needs.

In the Exposition will be found hundreds of exhibits of the latest developments, brought by manufacturers, to show the best that they have to offer, and demonstrated to illustrate the convenience and economy which may be secured by adopting this equipment. Hundreds of exhibits and thousands of pieces of apparatus will be on display; in attendance at the booths will be found men of the widest experience in solving all kinds of problems. Whether it be boilers, pumps, generators, piping installations or what not, experts will be ready to offer advice and suggestions to those who visit the exhibits and ask for information. He who is seeking can certainly find, if he will but make the best use of the opportunities which will be open to him.

In the Power Conference the foremost experts and engineers of the country will discuss problems of the widest scope covering the effect of power uses on civilization and the American home, the correlation of flood control and power development in the various river systems of the country, the economics of power station equipment and operation including the use of high pressure steam and modern methods of steam generation, and the best methods of transmitting power from the generating station to the points where it is to be utilized. The list of speakers is almost a roll-call of the men in the country who have been most prominently identified with the various aspects of power development on which they will speak. General Edgar Jadwin has been directly in touch with river control and power development problems for many years as chief of the Army Engineers; Alex Dow, president of the American Society of Mechanical Engineers, is known wherever electric power is used; G. A. Orrok has had a part in power plant development and construction in almost every department; for years, Thomas E. Murray has been engaged in the largest power plant developments in the country; others on the program are quite as well known and as prominent in their specialties.

Exhibits in the Coliseum will be more numerous and more attractive than ever before and some idea of what may be seen there can be gained from the following summary of the main features of the exhibit.

DIRECTORY OF EXHIBITS

AEROFIN CORP., 750 Frelinghuysen Ave., Newark, N. J. Booths 459-60.

Heating units will be shown with extended surface, made of non-corrodible metal and arranged for use in units or in banks for indirect systems.

AIR PREHEATER CORP., 25 Broadway, New York, N. Y. Booth 79.

Scene-in-action photograph of the Ljungstrom air preheater with modern models of complete boiler plant showing the adaptation of the air preheater to the boiler and photographs of installations.

ALBAUGH-DOVER MFG. CO., 2100 Marshall Blvd., Chicago, Ill. Booth 333.

This company will exhibit its full line of speed reducers of worm and spur gear type and also will display one unit made from standard parts that has a ratio of 800,000 to 1 speed reduction. Samples of high grade cut gears of all types will be included in the exhibit.

THE ALLEN-SHERMAN-HOFF CO., 225 S. 15th St., Philadelphia, Pa. Booth 103.

The company's Hydrojet system of ash handling will be illustrated by two pictures showing the motion action of the system, the first for a double water wall furnace bottom with ash hoppers and gates beneath, and the Hydrojet system installed below; this is similar to the arrangement on Boiler 22 at the Calumet Station of the Commonwealth Edison Co., except that the Hydrojet system is added beneath the ash gates. The second picture will illustrate the discharge of ashes into a sump and pumping them to an ash storage tank from which they are collected by truck. It will also indicate how ashes can be pumped for filling in low ground on the property.

ALEXANDER BROTHERS, 14 South St., Philadelphia, Pa. Booth 166.

Tentacular transmission belting will be shown in this exhibit with a typical drive such as found in a modern plant, showing extremely large speed reduction.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis. Booths 91-3.

Armor clad switch gear showing combined unit bus bar construction, circuit breaker, feeder connections and instrument transformers. Electric motors with roller bearings, hydraulic turbine runner models for high and low heads and centrifugal pumps.

AMERICAN ARCH CO., INC., 17 E. 42nd St., New York, N. Y. Booth 315.

Main feature in this exhibit will be the company's Type A unit supported side wall construction and additional features will be its air cooled bonded refractory wall construction and the American suspended arch.

AMERICAN BLOWER CORP., 6000 Russell St., Detroit, Mich. Booths 8-9.

Here will be shown the Sirocco flue dust collector for removing fly ash from the exhaust gases of powdered fuel plants, showing three types of collectors and an air filter. The filter will be so located that any dust which may escape from the collectors will pass through it, thus delivering thoroughly cleaned air. A complete plant equipment will be illustrated.

AMERICAN PULVERIZER CO., 18th and Austin Sts., St. Louis, Mo. Booth 137.

In this display, the main feature will be a working model of the American rolling ring coal crusher to demonstrate the method of action. Other equipment shown will be photographs of patented rings and descriptions of installations.

ANDREWS-BRADSHAW CO., 530 Fourth Ave., Pittsburgh, Pa. Booth 139.

Here will be shown a Tracyfier installed in a 42-in. boiler drum and operating under conditions approximately those found in a boiler, as closely as possible. Action will be visible through a 1-in. glass front and the Tracyfier will be shown in cross section to illustrate its operation. A complete disassembled Tracyfier will also be shown to permit study of its construction.

ARMSTRONG MACHINE WORKS, Three Rivers, Mich. Booths 403-4.

This company will exhibit its complete line of steam traps, including standard cast iron trap, steel traps for high pressures, Armstrong compound trap for large quantities of water at high pressures, as required in connection with separators. Also will be exhibited a glass model of the Armstrong trap operating on steam pressure, showing the entire cycle of operation of the inverted submerged bucket trap. The body of the trap, as well as the bucket, are of glass, and the demonstration shows how air binding is eliminated, also quick action of the valve to prevent wire drawing and self-scrubbing of the valve to eliminate frequent cleaning.

ATWOOD & MORRILL CO., Salem, Mass. Booth 137.

A new and specially designed damper regulator will be featured here, also will be shown valves for high temperature and pressure work in turbine and condenser installations and special valves for low-pressure superheating work.

AUBURN STOKER CORP., Auburn, Ind. Booth 447.

This booth will contain a display of the Auburn full mechanical stokers showing a full sized stoker in operation and also details of construction.

AUTOMATIC PRIMER CO., 111 W. Washington St., Chicago, Ill. Booth 466.

In this display, the main feature will be an Apco primer in combination with a horizontal centrifugal pump, direct connected to an electric motor. This will operate as an automatic sump pump unit to illustrate the feasibility of using horizontal centrifugal pumps on suction lifts.

THE BABCOCK & WILCOX CO., 85 Liberty St., New York, N. Y. Booths 171-2, 211-12.

In the exhibit of this company, which will be in conjunction with that of the Fuller-Lehigh Co., will be included a section of a 48-in. diameter Stirling drum, section of return-bend wrought steel economizer, section of forged steel superheater box, vertical forged steel header for 1400 lb. pressure, drum rivets in various stages of manufacture, high pressure water gage glass and other fittings. Also will be included a display of Babcock & Wilcox high-grade No. 80 firebrick in standard and special shapes and samples of Enduro and Toncan iron tubes including specimens which have been subjected to the action of various corrosive agents along with similarly treated steel and iron tubes.

BAILEY METER CO., 1050 Ivanhoe Rd., Cleveland, Ohio. Booths 213-5.

Here will be displayed a number of different styles and sizes of meter panel boards, also a complete line of Bailey boiler meters electrically and mechanically operated fluid meters, pressure and temperature recorders, tachometers and multi-pointer gages. The Bailey meter control for regulating the supply of fuel and air to boilers in a power plant according to the demand for steam and proper proportions to give best combustion efficiency will be shown in operation, demonstrating simplicity and flexibility. Most prominent among the features will be the Bailey automatic combustion control equipment shown as an operating exhibit.

BARCO MANUFACTURING CO., 1801 Winnemac Ave., Chicago, Ill. Booths 116-7.

In this space the main feature will be Barco flexible joints and lubricated plug valves, both in cut open section and some in electrically operated models to show the details of construction and the method of operation of joints and valves.

BARRETT-CHRISTIE CO., 37 S Clinton St., Chicago, Ill. Booths 401-2.

Here will be found Armstrong steam traps, Lumen machine bronze and a display of the Wood Shovel & Tool Co. Molybdenum shovel scoops. Other equipment shown will be the Instant Water heater, Durabla sheet and rod packings and high-pressure gage glasses.

BARTLETT-HAYWARD CO., Scott & McHenry Sts., Baltimore, Md. Booth 452.

This company will exhibit Fast's flexible couplings with detailed parts to show the all-metal, double-engagement, positively-lubricated action which takes care of misalinement without using flexible materials. Two spur gears, one on each shaft, will be shown continuously meshed, and the action illustrated by sectionalized models and photographs.

BEARIUM BEARINGS, INC., 261 Franklin St., Boston, Mass. Booth 2.

Special features in this exhibit will be selected numbers of the new processed rod from ¼ to 1 in. in diameter and in full lengths, especially designed for screw machine work, with smooth finish and size held to limits within 0.002 in. These are specially adapted for machining at high speed. Another feature will be a line of cored and solid bars and special castings, including airplane parts and liner-type bearings for cement and paper mill machinery, for Diesel engines, machine tools, motors and similar applications. Demonstration will be made of non-seizing and non-scoring qualities of Bearium by actual operation of a bushing at great heat and sudden cooling.

BERNITZ FURNACE APPLIANCE CO., 80 Federal St., Boston, Mass. Booth 145.

The Bernitz water wall, as recently developed by the company, will be the main feature of this display. A typical panel of this wall will be shown as applied to boiler furnaces, consisting of the usual bare tubes faced with the Thayer design of Bernitz carborundum blocks. Fastening devices as actually used will be shown. The water wall permits combustion right up to the face of the wall, thus promoting efficiency. Other features of the display will be the Bernitz carborundum ventilated floor, adapted for pulverized fuel and oil burning furnaces, designed for efficiency and effective ventilation; also Bernitz carborundum perforated and blank faced blocks of the S-100 type.

BETHLEHEM STEEL CO., Bethlehem, Pa. Booth 189.

Working models of Bethlehem-Dahl oil-burning equipment will be exhibited, together with parts of the Bethlehem pulverizer. Photographs and drawings will show the various types of pumps, Diesel engines and other equipment manufactured by the company.

BIGELOW-LIPTAK CORP., 5057 Woodward Ave., Detroit, Mich., Booth 174.

This company will display a complete line of furnace wall and arch products featuring wall construction in the display.

BLAW-KNOX CO., Pittsburgh, Pa. Booth 409.

This company's chief exhibit will be Blaw-Knox electroforged steel grating and flooring, and other equipment included will be radio and transmission towers shown in models, also preheaters, buckets and steel buildings.

BOTFIELD REFRACTORIES CO., Swanson & Clymer Sts., Philadelphia, Pa. Booth 436.

This company will feature Adamant and Adachrome refractory material for laying up of firebrick and for making patches in boiler settings, also application of this material by means of the Adamant gun. Other equipment to be shown will be the gun itself for applying refractory coatings

on plain exposed surfaces, requiring but one man for operation; also there will be the single ring arch in which heavy refractory construction is bonded by Adamant cement.

S. F. BOWSER & Co., Fort Wayne, Ind. Booth 164.

An important feature of this exhibit will be an Xacto meter in actual operation under conditions similar to those found in industrial plants. It is used for measuring liquids bought, sold or consumed, for measuring contents to and from tank cars, quantities used in batch or mixing processes and other operations where record of liquids is desired. Demonstrations will be made of its accuracy and in addition various types of force feed lubricators, oil filters, lubricating pumps, and self measuring pumps for industrial use will be shown.

BRISTOL CO., Waterbury, Conn. Booth 309.

Recording and indicating instruments for power plants, including measurements of pressure and vacuum, temperature, water level and electrical values, such as voltage, current and output will be found in this exhibit. As a special feature, recording thermometers for feed water and flue gas temperatures will be shown, also pyrometers for use with Diesel engines and liquid level gages for tanks and for boilers.

WM. BROS BOILER & MFG. CO., Nicollet Island, Minneapolis, Minn. Booth 421.

Three and four drum water tube boilers of bent tube design will be shown and a full line of fire box heating boilers of the welded type. One of the special features will be the welded tube type showing clearly all details of construction.

THE BROWN INSTRUMENT CO., 4578 Wayne Ave., Philadelphia, Pa. Booths 16-17.

In these booths will be found a display of large reproductions dramatically picturing the widespread use of the Brown electric flow meter which operates on the inductance bridge principle. In the center of the board will be a diagram illustrating the application of this bridge principle to meters and the operating principle will be demonstrated by lights periodically flashed on and off through cut outs in the diagram. Brown flow meters will be the main feature, in both indicating and recording models. These will be connected to a manometer arranged so that it can be actuated by visitors to the booth to give various pressure differentials and to demonstrate the principle and sensitivity of these meters to variation in flow. Also will be shown a circular chart recording model illustrating the planimeter and integrator action, permitting visitors to observe the record produced, functioning of the integrator and automatic planimeter measurement of records at the outer edge of the chart. Other accessories will be manometers, orifice plates, condensers.

BUILDERS IRON FOUNDRY, Providence, R. I. Booth 198.

This company will show its standard Venturi meter for boiler feed use and, in addition, its new Shunt steam meter of small, compact design for use on 2, 3 and 4-in. steam mains. The model on display will be shown in cross section to illustrate construction and operation.

BUFFALO FORGE CO., Buffalo, N. Y. Booths 123-5.

This company will show as the main feature of its display a new cinder eliminating fan in operation, also various smaller fans, heating equipment and a Universal iron worker.

BURNHAM & LANDSEY, 565 W. Washington St., Chicago, Ill. Booths 195-6.

Products of the Moore Steam Turbine Corp., Vulcan Soot Cleaner Co., and Centrifix Corp.

BUNDY STEAM TRAP CO., 39 Elm St., Nashua, N. H. Booths 454-5.

In this display the main feature will be a complete line of Bundy steam traps, showing special applications for various conditions and processes. Details will be shown, illustrating ground joints of the various connections, knife edge bearings to reduce friction and use of monel metal for valve seats and discs.

BYLLESBY ENGINEERING & MANAGEMENT CORP., 231 S. LaSalle St., Chicago, Ill. Booths 118-19.

The main feature in this display will be a model of a hydro-electric plant situated at Louisville, Ky., on the Ohio River which is nearing completion and will probably be placed in operation shortly after the first of the year. Other features will be a model of the Green Bay steam electric generating plant, a model of Prospect No. 2 development of The California Oregon Power Co., cross sectional model of one of the turbines in the Louisville hydro plant and model of the Chippewa Falls hydro project now under construction.

THE CARBORUNDUM CO., Perth Amboy, N. J. Booths 321-2.

This company will exhibit sections of boiler wall construction showing the use of Carborundum refractories for both water cooled and air cooled settings and including a section of the new Bernitz Thayer water cooled wall. A section of setting will be shown for a boiler equipped with chain grate stoker and employing straight Carborundum brick along the clinker zone.

A. W. CASH CO., Decatur, Ill. Booth 167.

Craig system of combustion control will be displayed here with master control operated by steam pressure. Also forced draft fans, boiler uptake dampers and models of pressure regulating devices.

CARRICK ENGINEERING CO., 538 S. Clark St., Chicago, Ill. Booth 312.

Carrick mercury-actuated master control of both hydraulic and electrical types will constitute the main feature of this booth. Other apparaus displayed will be a furnace regulator and an adjustable chronometer valve.

CARRIER ENGINEERING CO., 7501 Frelinghuysen Ave., Newark, N. J. Booths 460-1.

Heating and ventilating systems for buildings and industrial plants with air-conditioning apparatus, also equipment for generator cooling.

CARTER BLOXONEND FLOORING CO., 902 Walnut St., Kansas City, Mo. Booth 199.

This booth will be occupied with an exhibit of end-grain flooring designed to stay smooth under constant trucking, concentrated foot-wear and hard usage. The exhibit will consist of photographs of installations and sample panels of the flooring material.

THE CASEY-HEDGES CO., Chattanooga, Tenn. Booth 4.

Model of the company's multipass boiler with double circulation system will be shown, also a sample of riveting seams in extreme plate thickness. Blueprints will be displayed illustrating modern boiler settings and printed matter will be available describing various types of boilers which the company makes. A feature will be a sample of a forged steel sectional header.

CELITE PRODUCTS CO., 1320 S. Hope St., Los Angeles, Calif. Booth 10.

Sil-O-Cel insulating materials will constitute the main feature in this exhibit. A giant Sil-O-Cel insulating brick will be displayed, also a small demonstration furnace partly insulated and partly uninsulated with sections of breechings insulated on the inside and samples of the company's heat insulating materials, including Fraxite, high temperature cement and Celcote boiler wall compound.

THE CHAPMAN VALVE MFG. CO., 203 Hampshire St., Indian Orchard, Mass. Booths 33-4.

Here will be displayed chrome nickel steel gate valves and fittings for high pressure and temperature service, a motor unit for the operation of large valves and a full line of iron body gate valves for water and steam service. General service brass valves will be shown and a report displayed on the company's research work on materials for piping systems and strains in flanged joints.

CHICAGO BELTING CO., 125 N. Green St., Chicago, Ill. Booths 463-4.

This company will exhibit a line of leather belting in oak tanned and all other tannages; a line of leather packings and high pressure leathers for hydraulic machinery; Beltex liquid dressings for belts and belt grip stick dressing; also belt cements of various brands.

CHICAGO CHEMICAL CO., 6216 W. 66th Pl., Chicago, Ill. Booth 165.

In this booth the main feature of the display will be K. W. S. sodium aluminate as used for water treatment, with testing kits to demonstrate the method of treating boiler feed water, both directly in the boiler and in conjunction with lime and soda ash treating plants.

CHICAGO PUMP CO., 2336 Wolfram St., Chicago, Ill. Booths 1, 2, 3.

Centrifugal pumps and their application to power plant uses, including bilge and vacuum pumps, condensation pumps and receivers, boiler feeding and general service. Flush-Kleen sewage ejectors, with automatically cleaned screen; Condo-Vac system for heating plants.

CHICAGO RHOPAC PRODUCTS CO., 925 Wrightwood Ave., Chicago, Ill. Booth 200.

Main features in this exhibit will be metallic and soft packings, mechanical and molded rubber goods, special carbon dioxide testing sets.

CLARAGE FAN CO., Kalamazoo, Mich. Booths 226-7.

This exhibit will contain the new Clarage humidifier and a unit heater, both shown in operation. The heater consists of either cast iron or coil heating unit with combined motor and fan and the humidier is of new design especially adapted for jobs where low cost is essential.

CLEVELAND WORM & GEAR CO., 3249 E. Eightieth St., Cleveland, Ohio. Booths 430-1.

In these booths will be exhibited various types of standard worm gear speed reduction units, also the use of standard worm gearing in special machinery.

CLIPPER BELT LACER CO., Grand Rapids, Mich. Booth 437.

Complete line of the various models of Clipper belt lacers, fasteners, belt cutters and connecting pins. A special feature will be the new Clipper speed lacer now in use in many large plants and an electric sign of the scene-in-action variety will show a Clipper ship sailing the high seas.

CENTRIFIX CORP., 3029 Prospect Ave., Cleveland, Ohio. Booths 232-3.

Steam and compressed air purifiers will constitute the main feature of this display, other equipment included being fixtures for the recovery of entrainment in evaporating processes, line separators of various sizes and suction intake purifiers.

COKAL STOKER CORP., Wrigley Bldg., Chicago, Ill. Booths 189-90-91.

Complete exhibit will be made of the Cokal Automatic Pulverzone stoker, electrically operated, as a standard plant installation. This will be shown in operation the same as in a complete plant.

COMBUSTION ENGINEERING CORP. Booths 28-30.

See International Combustion Engineering Corp.

COMPRESSED SPRUCE PRODUCTS CO., INC., West Orange, N. J. Booths 448-9.

This exhibit will consist of Sprucolite pulleys in various types and of different applications in service. Also noiseless gears and pinions, rolls, wheels and blocks for absorption of noise and vibration, made from same material. This is the first showing of the company's products in the middle west.

CONNERY & CO., INC., Second St. above Erie Ave., Philadelphia, Pa. Booths 156-7.

This display will include the Connery expansion stiffener, air-cooled damper, expansion stack connection and the covering attachments for use in connection with breechings, uptakes, air and preheater ducts.

CONSOLIDATED ASHCROFT HANCOCK CO., INC., 100 E. 42nd St., New York, N. Y. Booths 67-8.

At this space the company will exhibit Consolidated cast iron and cast steel pop safety valves for working pressures up to 1500 lb.; Consolidated cast iron and cast steel economizer relief valves for like pressures; Ashcroft power control valves, for 1500 lb. pressure; Ashcroft cast brass pressure and vacuum gages for working pressures up to 1500 lb. and for vacuum; Hancock cast brass, cast steel and forged steel globe, angle, gate and check valves, for pressures up to 1350 lb.; Hancock cast steel drumhead stop and check valves for pressures up to 600 lb.; Hancock cast steel blowoff valves for pressure up to 1350 lb.

COOK ELECTRIC CO., 2700 Southport St., Chicago, Ill. Booth 146.

This company will exhibit metal bellows of monel, bronze or brass; also automatic fuel oil pumps and oil regulating devices, low-pressure gages, air regulating valves, damper regulators; in addition automatic steam valves, traps, flexible couplings and heat coil protectors.

COOKE SEAL RING CO., 30 N. Green St., Chicago, Ill. Booth 220.

Several pumps will be shown illustrating the installation of the Cooke Seal Ring and actual operation. One high pressure pump will be shown in actual operation and another part of the exhibit will include a horizontally split multi-stage pump with cover laid back, showing the use of the seal ring in the stuffing box. A refrigerating machine manufactured by the Cooke Electric Refrigeration Co. and using Cooke seal rings will also be shown, illustrating ammonia practice.

COPPUS ENGINEERING CORP., 344 Park Ave., Worcester, Mass. Booth 63.

Coppus Type C and Vano blowers for forced draft boiler equipment will be shown, also the Coppus Heat Killer for cooling and ventilating hot locations in any plant. The steam driven turbo boiler feed pump will be exhibited.

CRANDALL PACKING CO., Palmyra, N. Y. Booth 193.

The main feature of this display will be a full line of mechanical packings, fibrous and metallic and of raw materials from which finished products are made. These packings will be shown for all kinds of service.

CRANE CO., 836 S. Michigan Ave., Chicago, Ill. Booths 121-2, 162-3.

In this space the main feature will be a large steel gate valve shown in section and other equipment included will be bronze, cast iron, ferrosteel, cast steel and forged steel valves, fittings and flanges. These are suitable for use with complete range of pressures and temperatures found today in modern power plant and industrial installations.

CRANE PACKING CO., 1800 Cuyler Ave., Chicago, Ill. Booth 51.

A model showing the new John Crane method of expanding inlet ends of condenser tubes into lead-slugged fibres and packing outlet ends flush with metallic packing without ferrules will constitute the main feature of this display. Other equipment included will be metallic packing for all power plant services and a special display of centrifugal pump packing.

CROSBY STEAM GAGE & VALVE CO., 30 Church St., New York, N. Y. Booth 225.

Of this display the main feature will be gages and safety valves for all pressures and in all sizes. Other equipment exhibited will be a line of relief valves, blowoff valves, indicators and whistles, also gage testing machine for pressures up to 25,000 lb.

THE CUTLER-HAMMER MFG. CO., 12th and St. Paul Sts., Milwaukee, Wis. Booths 110-12.

As a main feature of this display will be found the type 9583 AAA, across-the-line automatic starter in operation. Other features will be the complete line of C-H across-the-line starters and also the Cutler-Hammer (Dean) valve control equipment for use in large buildings. A line of wiring devices will also be exhibited.

THE CUTTER ELECTRICAL & MFG. CO., 19th and Hamilton Sts., Philadelphia, Pa. Booths 310-11.

A 2000 amp. type LG 3 pole overload and time limit carbon circuit breaker will be the main feature of this display, as used in connection with alternating current circuits up to and including 550 v. This breaker will be arranged for remote operation and will be non-closable at any point of the solenoid closing stroke, if closing is attempted against a short circuit or an overload. There will also be shown a number of U-Re-Lites consisting of an I-T-E circuit breaker enclosed in steel box. These will be shown in capacities of 1000 amp. and under for both alternating and direct current service. Another feature will be a 2000 amp. double pole field switch with two automatic field discharge clips and there will also be shown a semi-automatic transformer circuit breaker of 1000 amp. capacity, 3 pole type.

THE DAMPNEY CO. OF AMERICA, Hyde Park, Boston, Mass. Booth 75.

This company will exhibit its complete line of Apexior protective coatings for metal surfaces and will show the equipment developed for applying this expeditiously to internal surfaces of boiler and economizer tubes. There will also be available for inspection a number of samples of boiler tubes which have been pickled for removal of mill scale and later Apexiorized, showing the condition of the coating after various lengths of service periods.

G. M. DAVIS REGULATOR CO., 422 Milwaukee Ave., Chicago, Ill. Booth 86.

Automatic valves for pressure regulation will constitute main feature in this exhibit. Other equipment will include

non-return valves for bleeder lines of turbines and valves for special pressure and back pressure regulation.

DEARBORN CHEMICAL CO., 310 S. Michigan Ave., Chicago, Ill. Booth 420.

Samples will be displayed of Dearborn scientific water treating preparations, Dearborn cleaners, No-Ox-Id rust preventive and Dearborn lubricating oils. Dearborn laboratory processes will be illustrated by moving pictures.

DETROIT BELT LACER CO., Detroit, Mich. Booth 471.

DEWALT PRODUCTS CO., Leola, Pa. Booth 342.

In actual operation will be shown the DeWalt Wonder Worker woodworking machine making various cuts of lumber; also the DeWalt jointer attachment for direct attachment to the electric motor of the Wonder Worker or fitted to a stand, to be direct motor driven from a 1½-hp. electric motor.

DIAMOND POWER SPECIALTY CORP., Detroit, Mich. Booths 178—9.

This exhibit will be a portrayal of the complete story of soot and ash deposits in boilers, their cause, effect and methods of removal; samples of soot blower elements will be shown, also both hand and electrically operated automatic valved soot blowers.

DODGE MFG. CORP., Mishawaka, Ind. Booths 418-9.

In this display will be found equipment for power transmission, including split pulleys with wood bushings, hanger shaftings and rope drive equipment of all sorts.

DRAKE NON-CLINKERING FURNACE BLOCK CO., 5 Beekman St., New York, N. Y. Booth 148.

Drake armor-clad water wall, the SX air cooled wall, the U & T air cooled wall and a complete display of non-clinkering blocks will make up the exhibit in this booth.

DRY QUENCHING EQUIPMENT CORP. Booths 54-6.

See International Combustion Engineering Corp.

C. A. DUNHAM CO., 450 E. Ohio St., Chicago, Ill. Booths 173, 210.

Working unit will be shown of the Dunham differential vacuum heating system including boilers, series pump and radiator, also differential vacuum pump, condensation pump and receiver, both units in operation and a display of thermostatic radiator traps, float and thermostatic traps, return traps, air eliminators, packless radiator valves, and other equipment all shown in sectional form.

DURAMETALLIC CORP., 806 Cobb Ave., Kalamazoo, Mich. Booth 411.

The main feature in this display will be Durametallic flexible self-lubricating packing in spiral and bar form. This is made in five different grades of different metals or combinations and all five grades will be shown. Die moulded packing rings and ring sets will be shown in great variety. In addition, samples of a new plastic packing called Magic Mud and a wedge packing will be exhibited.

DUST RECOVERY CO., 15 Park Row, New York, N. Y. Booth 75.

Machinery for recovering dust and the prevention of formation of explosive or inflammable mixtures, also apparatus for conveying and collecting the dust recovered.

ECONOMY PUMPING MACHINERY CO., 3431 W. 48th Pl., Chicago, Ill. Booth 11.

Here the feature will be pumping machinery, including double-suction, horizontal, split-case centrifugal pumps in capacities from 50 to 3000 g.p.m., heavy duty multi-stage pumps with horizontal split case and one-piece bronze diaphragm for volute design in every stage, automatic condensation pumps and receivers, showing one unit for 5000 sq. ft. capacity against 10 lb. pressure, centrifugal vacuum pumps for handling 16,000 sq. ft. of condenser capacity and Caisson pumps with capacity of 300 g.p.m. against 120 ft. head.

EDWARD VALVE & MFG. CO., 1200 W. 145th St., East Chicago, Ind. Booth 79.

This company will feature one of its non-return valves which is being furnished for the new Powerton station of the Super-Power Co. of Illinois. These valves are built for 12-in., 900-lb. specifications and provided with reduced ports, having yoke construction of double combination radial and end-thrust ball bearing types for ease in closing against high pressures. Smaller valve lines will also be exhibited, including offset flanged forged steel for various pressure classes.

EHRET MAGNESIA MFG. CO., Valley Forge, Pa. Booth 88.

Display of 85 per cent magnesia pipe covering and blocks, also high temperature insulation in various mixtures and types. The display will show the lightness, strength and permanent effectiveness of this material, also details of chemical and manufacturing processes in producing it.

LEWIS M. ELLISON, 214 W. Kinzie St., Chicago, Ill. Booths 5-6.

This exhibit will display Ellison pointer draft gages with straight line movement and a new line of dial type draft gages. Also Ellison inclined and vertical tube types in both stationary and portable form and the new U path steam calorimeter with extreme accuracy.

EVERLASTING VALVE CO., 1 Exchange Pl., Jersey City, N. J. Booth 45.

On the corner of this display will be the Everlasting twin blow-off unit, a combination of two Companion angle valves in the 600-lb. type, but also suitable for lower pressures. The Duplex blow-off unit special, a combination of Companion angle valve and the Everlasting valve special will also be displayed, limited to 500 lb. maximum pressure because for above this pressure a lifting type valve is more suitable. An assortment of regular Everlasting valves and Flatplug valves will be included in the exhibit with the tandem valve, model X and special water column valve to protect the operator when replacing broken gage glasses or repairing leaky try cocks.

EX-CELL-O TOOL & MFG. CO., 1469 E. Grand Blvd., Detroit, Mich. Booth 316.

Precision details for Diesel engine fuel injection will be featured, including a display of parts and a demonstration of the accuracy of fits of these parts. Other features will be a display of standard XLO drill jig bushings and internal grinder spindles.

FAFNIR BEARING CO., New Britain, Conn. Booths 334-5.

Products to be exhibited will include the company's line of standard ball bearings, such as single row radial, double row, thrust, magneto type and ball bearing transmission equipment, including hanger boxes, pillow blocks, blower boxes and loose pulleys. Also will be displayed the wide inner ring ball bearings with self locking collar for straight shaft application. A special feature will be a machine showing the small amount of power required to drive ball bearings under load in operation, with the bearing mountings shown and a drawing of the principle of deep race ball bearings. Another moving display will be shafting mounted on ball bearing transmission units and driven by a smaller motor.

FAIRBANKS, MORSE & CO., 900 S. Wabash Ave., Chicago, Ill. Booths 129-30 and 154-5.

Diesel engine generating set will constitute a main feature of this display, which will include also motors and pumps. Among the motors will be shown a 25-hp. sectional ized squirrel cage motor "running on a little air," an alternating current, direct current motor-geneartor set, a sectionalized type HAC self ventilating motor of latest design, sectionalized double squirrel cage rotor, direct current motor, single phase motor and vertical squirrel cage motor. Pumps will be shown including a high-speed, high-head ball bearing centrifugal pump in operation, a sectionalized moderate-head, moderate-speed pump of similar drive, F-M Price-Well turbine pump and head and the new side-suction centrifugal pump.

FILTRATORS CO., 96 Liberty St., New York, N. Y. Booth 303.

This company will display Filtrators for keeping boilers permanently clean. The two types shown will be the air cooled and the water cooled and the method of application and use of the apparatus will be fully demonstrated.

THE FISHER GOVERNOR CO., INC., Marshalltown, Ia. Booth 37.

Here will be found a new Fisher continuous sample head and two jet mixers used particularly in oil refining, also liquid level controllers, float valves, steam traps, constant pressure pump governors, excess pressure pump governors, pressure reducing valves, pressure regulators, lever valves, boiler gas fuel governors and gas regulators.

FOSTER ENGINEERING CO., 109 Monroe St., Newark, N. J. Booth 160.

Foster automatic valves will be shown here, including a line of some thirty valves; also sight-flow box in operation and complete sectional models of Foster flexible ball joints. A particular feature will be made of drop forged cast steel chrome construction for high boiler pressures and temperatures, one important exhibit being a 6-in. angle all chrome Foster non-return stop valve.

FOSTER WHEELER CORP., 111 Broadway, New York, N. Y. Booths 180-3.

Size D aero unit coal pulverizer will be shown, direct driven by motor at reduced speed and equipped with magnetic separator. This will be operated to demonstrate the principle of action. Full size sections will be shown of a Foster sectional air heater and a Foster water-cooled furnace surface, also sections of various superheater surfaces, including forged steel radiant heat type. Foster economizer surface and tubular oil still construction will be shown in section, also the Foster water back. On display will be a superheater element which has been in active service in Chicago for more than 20 years. Photographs and drawings will illustrate the company's equipment, including condensers, steam jet air pumps, evaporators and feed water heaters. Also cooling towers will be illustrated and an exhibit made of Crescent brand copper and brass tubing and pipe.

THE FOXBORO CO., INC., Foxboro, Mass. Booth 61.

Featured in this display will be the company's new steam flow meter, a recent development. Other parts of the exhibit will be indicating and recording pressure gages and thermometers, multiple pen recorders for pressure and temperature, draft gages and a general line of power plant instruments.

FULLER LEHIGH CO., Fullerton, Pa. Booths 168-70.

Sectional drawings, photographs and operating data will be shown of typical Fuller Lehigh storage and direct-fired pulverized coal installations, of Bailey water cooled furnace wall installations, of Fuller Lehigh pulverized coal equipment, consisting of mills, feeding equipment burners, transport system, waste heat dryers and furnace walls. Bailey water cooled furnace wall will be shown erected in place, with various types of refractory faced blocks and water tube construction; also samples of Bailey refractory faced and bare iron water cooled furnace blocks and glass inspection door. Model of the Calumet burner for pulverized coal.

FURNACE ECONOMY CO., 407 S. Dearborn St., Chicago, Ill. Booth 462.

Economy air cooled furnace wall will be the main feature in this booth, no other equipment being exhibited. The Economy wall will be shown in detail and descriptive literature will be available.

FURNACE ENGINEERING CO., INC., 5 Beekman St., New York, N. Y. Booths 96-7.

Exhibited here will be the Simplex unit system of pulverizing and burning coal and the Drake armor-clad wall construction. An animated picture will show the workings of the unit system and photographs will show complete installations.

THE GARLOCK PACKING CO., Palmyra, N. Y. Booth 453.

Mechanical display will be made on a mechanical model of Garlock oil return packing and Garlock-800 Varitemp ammonia packing working on a piston rod. There will also be complete exhibit of various lines of packing which the company manufactures to give an idea of Garlock service for every packing problem.

GRAVER CORP., East Chicago, Ind. Booths 150-1.

In this display the main feature will be water treating equipment including tanks and other steel plant equipment for water storage and water towers.

A. P. GREEN FIREBRICK CO., Mexico, Mo. Booth 175.

Refractory products and plastic material for high temperature work, air setting cement, special shapes for fire brick.

GRINDLE FUEL EQUIPMENT CO., Harvey, Ill. Booths 438-9.

Pulverized coal installation, hopper systems for firing boilers, cement kilns and furnaces of various kinds with special emphasis on the unit pulverizer feeder and the Type Z feeder for pulverized coal.

GRINNELL CO., Providence, R. I. Booths 441-2.

The principal feature of this display will be the Grinnell Triple XXX line products, designed to meet the requirements of super power for fabricated piping materials of unusual strength. It includes material designed for 400, 600 or 900 lb. working pressure and the various Triple XXX laps used will be demonstrated at the booth. Another new development will be an industrial type Thermolier, or unit heater of large capacity and flexibility, also the Grinnell Equiflo valve for forced hot water heating systems will be demonstrated. Standard sprinkler head and the Quartz bulb sprinkler head will be on exhibition and the complete line of hangers for power installations.

GRISCOM-RUSSELL CO., 285 Madison Ave., New York, N. Y. Booths 426-7.

Here will be found the company's products including evaporators and heat exchange apparatus, such as Reilly evaporators and water heaters, U-Fin generator air cooler, Stratton steam and air separators and Griscom-Russell Bentube evaporators.

HAGAN CORP., Pittsburgh, Pa. Booths 58-9.

Working demonstration will be made of the Hagan steam purifier, systems of control, including the new electric control and of the Hall system of boiler water conditioning.

JOSEPH HARRINGTON CO., Harvey, Ill., Booths 438-9.

This company's display will show a complete line of stoker equipment for small and medium size boilers, including the King Coal stoker, especially designed for medium size boilers and a new junior stoker to meet the demand for stokers under fire box and other low set boilers.

ARTHUR HARRIS & CO., 212 N. Curtis St., Chicago, Ill. Booth 222.

Floats for tanks, vats and similar uses will be the main feature of this display and in addition will be shown expansion joints, Harbronz and other copper work.

THE HAYS CORP., Michigan City, Ind. Booth 313.

This corporation will exhibit its new motor-driven water operated CO_2 recorder, its line of pointer type draft gages, improved gas analyzers, new compact portable test set and Hays inclined tube, vertical tube and U-tube gages for draft, pressure and differential.

E. VERNON HILL CO., 121 N. Clark St., Chicago, Ill. Booth 338.

Air testing instruments will be shown with new designs of wet and dry bulb thermometers, filter gages, draft gages, Pitot tubes, dust testing outfits, CO_2 analyzers, psychrometers, thermometers, anemometers, microscopes and stop watches.

HIMELBLAU, AGAZIM & CO., 30 N. Dearborn St., Chicago, Ill. Booth 65.

This company acts as district representative for the Ames Iron Works, Boiler Engineering Co., Boiler Room Improvement Co., General Air Filters Corp., Korfund Co., Inc., Schade Valve Mfg. Co., Sterling Engineering Co. and Lehnco Co. Products exhibited will be, for the Ames Iron Works, automatic side and center crank engines, also unaflow engines of horizontal and vertical types; for the Boiler Engineering Co., the Beco baffle with corrugated expansion joint; for the Boiler Room Improvement C., the Eclipse smoke indicator and the McNeill liquid level gage, the smoke indicator being used to determine the quantity of smoke passing through the stack by the obstruction which it makes to the visibility of a light and a system of mirrors, the image being brought down to a point easily observed by the fireman; for the General Air Filters Corp., air purification as used for stationary and automatic air filters; for Korfund Co., Inc., the Vibro damper and Korfund material for prevention of noise and vibration; for the Schade Valve Mfg. Co., regulating and reducing valves for power plants and industrial manufacturing plants; for the Sterling Engineering Co., heating specialties, particularly the Sterlco Thermotrol to replace radiator valves and regulate the temperatures of radiators; for the Lehnco Co., pressure regulators for boilers and for automatically controlling equipment according to demand.

ILLINOIS ENGINEERING CO., 21st St. and Racine Ave., Chicago, Ill. Booths 405-6.

A glass model of the Eclipse ¾-in. figure 35 steam trap will be shown operating under actual working conditions. The set up of the exhibit will include also an electric boiler, boiler feed pump, piping and other features. The operating trap will be so displayed as to demonstrate simplicity of construction, ease of disassembling, quick action, large valve travel and freedom from wiredrawing.

ILLINOIS STOKER CO., Alton, Ill. Booth 138.

Detailed drawings, photographs and charts illustrating latest installation of chain grate stokers will be featured in this exhibit, also the links, dampers and other important parts of the equipment, to give a comprehensive idea of construction, operation and maintenance.

INGERSOLL-RAND CO., 11 Broadway, New York, N. Y. Booths 108-9.

Cameron pumps and special features of Ingersoll-Rand surface condensers, Multi-stage boiler feed pump for pressures up to 1500 lb. with improved thrust device and Kingsbury thrust bearing.

INSTANT WATER HEATER SALES DIVISION, 332 S. Michigan Ave., Chicago, Ill. Booth 401.

This company's exhibit will consist of an Instant copper tube steam water heater and a new Instant flow control for the steam supply to the heater. This exhibit will be connected to steam and water lines generating hot water at the booth and a cut-out section will show interior construction.

INSULATING PRODUCTS CO., 1553 W. Madison St., Chicago, Ill. Booth 472.

Foster economizers insulated with Webers No. 48 insulating cement as installed in the New York Steam Corp. will be illustrated by photographs covering one entire wall of the booth. Other equipment will be panels of air ducts taken from actual installations as insulated with No. 48 cement.

INTERNATIONAL COMBUSTION ENGINEERING CORP., 200 Madison Ave., New York, N. Y. Booths 28-30, 54-6.

In the exhibit of this company will be found displays of Combustion Engineering Corp., Heine Boiler Co., Ladd Water Tube Boiler Co., Dry Quenching Equipment Corp., and International Coal Carbonization Co., all subsidiaries of the International Combustion Engineering Corp. Principal features of the exhibit will be two panels, each 9 by 5 ft., showing enlarged reproductions of tables appearing in the 1927 Pulverized Fuel Report of the Prime Movers Committee of the N. E. L. A. This report shows all the power plants in United States and Canada containing boilers of 500 hp. and over, which burn pulverized fuel with storage equipment, and check marks cut out of the panel material and illuminated from behind will indicate Lopulco equipment in these stations. Panels will be placed end to end on pedestals, the reverse side forming a continuous wall 18 ft. long which will be draped and used as background for other panels devoted to the various types of boilers manufactured by this company and showing also typical settings. Principal equipment exhibits will be a Couch adjustable burner for horizontal firing of pulverized fuel; a Lopulco preheated air burner; a model of the C-E fin wall; a model of the C-E air preheater showing the "S" flow design and new type clean-out doors; the newly developed C-E liquid level indicator for projecting the image of a water column at the operating floor level. On tables will be found elements of the various stoker and pulverized fuel products, such as grate bars, mill hammers and the like. Three scene-in-action displays, showing various types of steam generating units, will be used and the Dry Quenching Equipment Corp. and International Coal Carbonization Co. will have panels showing typical layouts of their equipment with descriptive literature.

THE INTERNATIONAL NICKEL CO., 67 Wall St., New York, N. Y. Booths 141-2.

Commercial forms of monel metal will be featured, including rods, sheet tubing, forging, castings. This will be augmented by an interesting collection of samples of various parts of power plant equipment manufactured from monel metal and loaned for the purpose by various manufacturers.

IRVING IRON WORKS CO., 3rd and Creek Sts., Long Island City, N. Y. Booths 432-3.

Irving subway open steel ventilating flooring will be shown in type M, also the company's streamline modification of this flooring and the Irving Vizabledg Safsteps. Another feature will be the Irving unified system of reinforcement and surface armor for concrete bridge floors.

JENKINS BROS., 80 White St., New York, N. Y. Booth 202.

The company will display bronze and iron globe, angle, check cross and Y valves, in all types for standard, medium and extra heavy pressures; also it will exhibit its rapid action Selclo modulating and other special valves and steel valves for high pressures and high superheat. There will be a full line of molded and rolled mechanical rubber goods and of the Moncrieff gage glasses displayed.

JOHNSON SERVICE CO., Milwaukee, Wis. Booth 300.

Temperature control systems for steam and hot water heating, details of apparatus and demonstration of method of action.

W. A. JONES FDRY. & MACHINE CO., 4401 W. Roosevelt Rd., Chicago, Ill. Booth 90.

In this booth will be found enclosed spur and worm gear speed reducers including standard double type spur gear reducers and a new type of heavy duty worm gear reducers in two sizes.

M. W. KELLOGG CO., 7 Dey St., New York, N. Y. Booth 78.

Latest developments in the manufacture of piping materials for high-pressure steam service; also Dean high-pressure, power-operated parallel slide and swing gate valves.

KELLEY VALVE CO., 372 W. Grand Ave., Chicago, Ill. Booth 64.

Kelley self grinding globe and angle valves in all types and materials of construction, also Kelley controllers.

KENNEDY-VAN SAUN MFG. & ENGRG. CORP., 50 Church St., New York, N. Y. Booth 445.

The main feature of this display will be a scene-in-action of the Kennedy air-swept ball and tube mill. Other equipment shown will be a large photograph of the S. S. Mercer, the first steam ship crossing the Atlantic using pulverized fuel and special literature will be available giving the history of its voyage.

KIELEY & MUELLER, INC., 34 W. 13th St., New York, N. Y. Booth 402.

In this display the main feature will be high and low-pressure regulating and reducing valves, damper regulators and high-pressure water line controllers. Other features of the exhibit will be the company's regular line of damper regulators and return and lift traps.

THE KORFUND CO., Inc., 235 East 42nd Street, New York. Booth 66.

Machinery in operation will be shown set on Korfund vibro-dampers to eliminate vibration and noise.

THE LABOUR CO., Chicago Heights, Ill. Booth 440.

This company will operate one of its self-priming centrifugal pumps, equipped with glass suction line to demonstrate the ability of the pump to handle air. It will display also a portable unit direct connected to a gasoline engine for contractors' service and castings made from an acid-resisting metal known as Elcomet, which has recently been developed.

THE LEAVITT MACHINE CO., Orange, Mass. Booth 148.

This company's display will consist of a practical demonstration of Dexter valve reseating machines, including those for reseating globe valves, those for gate valves and those for refacing pump valve seats.

ERNEST E. LEE CO., 115 S. Dearborn St., Chicago, Ill. Booths 135-9, 146-9.

This company represents in the Chicago district, the Northern Equipment Co., showing the Copes feed water regulator, thermostat and valve; the Manistee Iron Works Co., showing a 1000 g.p.m. eight-stage boiler feed pump; Leavitt Machine Co., showing gate and globe valve reseating machines in operation; Drake Non-Clinkering Furnace Block Co., showing blocks and wall construction for high temperature furnaces; Andrews Bradshaw Co., showing the installation of a Tracyfier in a boiler; American Pulverizer Co., showing model of the American ring crusher in operation; Atwood & Morrill Co., showing reverse current valves, condensate drainers and other valves; Illinois Stoker Co., showing forced and natural draft chain grate stoker equipment; Uehling Instrument Co., showing Apex CO_2 instruments.

LIBERTY ELECTRIC CORP., Stamford, Conn. Booth 306.

The main feature of this display will be Liberty valve operators for remote control in valve operation. Other features will be switch equipment of various kinds.

GEO. B. LIMBERT & CO., 570 Fulton St., Chicago, Ill. Booths 131-2.

Fabricated pipe will constitute the main feature in this exhibit including a welded manifold showing swaging, Vanstone laps, welded flanges and welded outlets. Bolted to this manifold will be an 8-in. extra-heavy special compound bend made with small radius. Another small welded header will feature reducing Van Stone lap and welded spuds for use on suction lines and small heating coils for kiln work. Other equipment exhibited will be special cast steel, cast iron flanged pipe fittings for 125 lb. standard, a special angle ell, also a 10-in. extra heavy flanged standard, cast-steel, reducing side outlet, tee for 250 lb.

THE LINDE AIR PRODUCTS CO., 30 E. 42nd St., New York, N. Y. Booth 324.

This company's exhibit will consist of equipment and supplies for oxy-aceylene welding and of specimens showing the wide application of this process. Some of the specimens will

be cast iron pipe with bronze welding with the new Shear-Vee joint. Dependability of the ox-welded joint will be emphasized.

LOCKE REGULATOR CO., Salem, Mass. Booths 454-5.

Exhibit will be made of pressure reducing valves, damper regulators, automatic engine stop equipment, float control valves, non-return valves, hydraulic regulators, balanced valves, exhaust relief valves and safety shut off valves. Special stress will be laid on a damper regulator which is of new design and greatly improved.

J. E. LONERGAN CO., 211 Race St., Philadelphia, Pa. Booths 454-5.

This company's main display will be along the line of safety valves and gages with water gage fittings and oil cups. A full line of the company's products will be illustrated.

LOVEJOY TOOL WKS., 319 West Ohio St., Chicago, Ill. Booth 332.

THE LUNKENHEIMER CO., Cincinnati, Ohio. Booths 184-5.

Representative exhibits of various steel, monel, iron body and bronze valves; valves for high pressures with monel mountings; electrically operated gate valves; large and small valves for extremely high pressures and a full line of valves for all power plant purposes.

JOHN W. MABBS, 431 S. Dearborn St., Chicago, Ill. Booth 229.

In this space will be found products of the Marsh Valve Co., Thermidaire Corp., Direct Control Valve Co., and the Mabbs Rawhide Packing. The products displayed will be Mabbs rawhide packing, Marsh packless radiator valves, Thermidaire unit heaters.

MANISTEE IRON WORKS CO., Manistee, Mich. Booth 136.

Roturbo pumps featuring 8-stage horizontally split pumps, also single stage-volute pumps and the Roturbo impeller.

MARION MACHINE FOUNDRY & SUPPLY CO., Marion, Ind. Booths 407-8.

Here will be shown type AB Marion soot blowers with balanced head and independently operated valve-at-head. Welded Venturi nozzles and high temperature elements of special alloy will be exhibited, also the Marion Gulf Stream water heater for furnishing hot water instantly wherever steam is available.

MECHANICAL MFG. CO., Pershing Rd. and Loomis St., Chicago, Ill. Booths 465-7.

MERRICK SCALE MFG. CO., Passaic, N. J. Booth 308.

Merrick conveyor weightometer will be displayed for weighing all classes of material which is conveyor handled, the scale being shown in operation weighing coal. Merrick mechanical Weighman for weighing pulverized coal, crushed coal, boiler feed water or any material which is hopper handled will also be shown in actual operation weighing water.

MIDWEST PIPING & SUPPLY CO., St. Louis, Mo. Booth 204.

Globack joints for 600, 900 and 1350 lb. pressure will here be shown having spherical back face on the lap of existing tongue and groove and male and female Van Stone joints. The flange contact surface is also spherical to provide extra metal in the lap area.

MODINE MANUFACTURING CO., Racine, Wis. Booths 340-1.

This company will display a working exhibit of Thermodine unit heaters, cabinet heaters and concealed heaters, all three products being fully displayed in the exhibit.

MOREHEAD MANUFACTURING CO., 4895 Grand River Ave., Detroit, Mich. Booth 413.

In this display the main feature will be a direct return trap of average size, which is the typical prime mover in Morehead back to the boiler and Morehead condensation drainage systems. Other equipment included will be a Morehead receiver and various parts of the Morehead prime mover trap.

MOORE STEAM TURBINE CORP., Wellsville, N. Y. Booth 196.

This company will display its combined turbine and reduction gearing, a new development, also a turbine-driven boiler feed pump complete with pump governor and a 1500 hp. 3-bearing reduction gear pinion.

MOTOR TOOL SPECIALTY CO., 14 E. Jackson Blvd., Chicago, Ill. Booth 87.

Snap-On socket wrenches will be the chief feature in this space, including a standard line of sockets from ¼ to 1½ in. U. S. Standard opening with a number of new additions. These will be shown individually as well as in complete sets and will be accompanied by other hand tool equipment including Blue Point open end wrenches, Boxocket wrenches, Simplex open and ratcheting wrenches, pipe wrenches, chisels, punches and other hand tools.

MULTICELL RADIATOR CO., 80 Terrace, Buffalo, N. Y. Booth 434.

MURRAY IRON WORKS, Burlington, Iowa. Booth 330.

J. W. MURPHY CO., 431 S. Dearborn St., Chicago, Ill. Booths 313-4.

In this space will be found the products of the Hays Instrument Co. and also Rowan starters showing a complete line of the Rowan automatic motor starting boxes, Esterline meters and also the combustion testing instruments of the Hays Co. all shown in actual operation.

NASH ENGINEERING CO., So. Norwalk, Conn. Booths 80-2.

Vacuum and condensation pumps for removing gases, air and condensate from heating systems of Jennings-Hytor type; circulating pumps for hot water condensing systems and sewage ejection.

NATIONAL CO., INC., Cambridge, Mass. Booth 76.

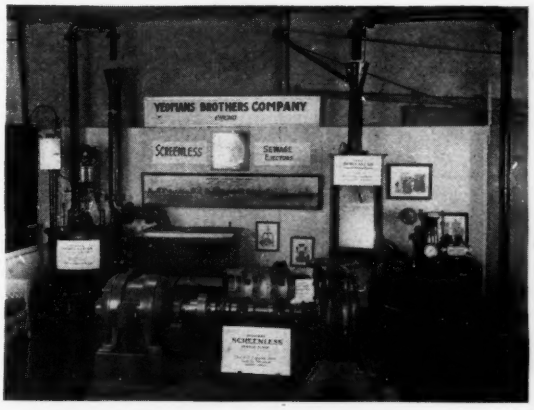
Water column illuminator for distant reading of water level.

NATIONAL AIR FILTER CO., 5130 Ravenswood Ave., Chicago, Ill. Booth 443.

In connection with this exhibit the main feature of the display will be air filtration equipment of six distinct types, showing details and method of operation.

NATIONAL POWER CONSTRUCTION CO., Fisher Bldg., Chicago, Ill. Booth 444.

By means of photographs and a list, the jobs recently completed of actual settings in the largest power plants in the country by this company will be shown. It is not possible to show equipment, but full demonstration will be made of the company's work.



NATIONAL TUBE CO., Frick Bldg., Pittsburgh, Pa. Booths 301-2.

Shelby seamless tubing, National boiler tubes and pipe, including welding, scale-free pipe and Van Stone flanges.

NAYLOR-HICKEY CORP., 643 Washington Blvd., Chicago, Ill. Booths 454-5.

This company will have on display the steam specialties of the J. E. Lonergan Co., those of the Bundy Steam Trap Co., and those of the Locke Regulator Co.

THE HERMAN NELSON CORP., Moline, Ill. Booths 20-21.

This company's featured display will be the Herman Nelson hiJet unit heater of which three standard models will be shown. Other products displayed will be the Univent, especially designed for schools, offices and similar buildings; the Herman Nelson invisible radiator, built into a wall or partition, and Wedge Core radiator sections for heating, cooling and drying.

NORMA-HOFFMANN BEARINGS CORP., Stamford, Conn. Booths 35-6.

Complete line of ball, roller and thrust bearings which the company manufactures will be shown here, also a number of reduction gear units fitted with ball and roller bearings in section to show the method of mounting.

NORTHERN EQUIPMENT CO., Erie, Pa. Booths 135 and 149.

Chief among the several pieces of new equipment to be shown at the show will be a new combined feed water regulator and pressure control valve. Also a new feature will be the orifice valve for condensate drainage control, Copes outboard ball bearing valves and the new tripper type ther-

mostat. Included in the display will be standard Copes feed water regulator in a moving exhibit showing the functioning of the regulator in actual service, also the pump governor and valve movement indicator and the Copes control valve.

WM. W. NUGENT & Co., 410 N. Hermitage Ave., Chicago, Ill. Booth 192.

Main feature of this display will be oil filters and their adaptation for reclaiming oil. Other equipment shown will be oiling devices, oil pumps and telescopic oilers for moving parts of machinery, also sight feed oil valves.

NUWAY BOILER & ENGINEERING Co., 53 W. Jackson Blvd., Chicago, Ill. Booth 115.

Nuway water wall boiler and the Nuway Super-circulation boiler with details shown by separate parts and photographs and illustrations.

THE S. OBERMAYER Co., 2563 W. 18th St., Chicago, Ill. Booths 456-7-8.

Here will be shown as a main feature a new cement gun operated by one man, with container to be placed outside the furnace in which it is being used. Other equipment will be the company's Ramtite plastic fire brick and high temperature cement.

PAIGE & JONES CHEMICAL Co., Hammond, Ind. Booth 339.

In this display the main feature will be an exact duplicate of a 100,000-gal., double unit Paige & Jones rapid rate upward flow Zeolite water softener, built exactly to scale. There will also be an exhibit of FFF boiler feed water treatment,

in conjunction with the wayside tank system used by railroads and by boiler plant operators.

PEABODY COAL Co., 322 S. Michigan Ave., Chicago, Ill. Booths 152-3.

This exhibit will be made by the Modern Coal Burner Co., showing a small automatic stoker designed for the average heating plant.

PEABODY ENGINEERING CORP., 110 E. 42nd St., New York, N. Y. Booth 423.

This company is showing a Peabody combined oil and pulverized coal burner as installed in the front wall of a furnace for marine practice and also for industrial use. A new insulated front plate will be demonstrated for use where preheated air is adopted allowing the entire windbox front to be insulated, so as to protect firemen from excessive heat. Another feature will be a high capacity gas burner in use in the natural gas region which can be installed either as a straight gas burner, as a combined oil and gas burner, as a combined coal and gas burner or as combined coal, oil and gas burner.

THE PERMUTIT Co., 440 Fourth Ave., New York, N. Y. Booth 224.

Principal and most interesting in the features of the exhibit will be a model of water softening and filtering equipment as used in industrial plants. This is about 4 ft. long and made exactly to scale after a large commercial unit which delivers 100,000 gal. a day, even small pipes and strainers in the interior of the water softening tank being reproduced in miniature. Also shown in the exhibit will be Ranarex instruments for recording CO_2 gas density, ammonia gas and similar data, using purely mechanical means of obtaining the records. Both rapid and slow regenerating water softeners of Zeolite type will be shown for small as well as large plants.

PITTSBURGH PIPING & EQUIPMENT Co., 43rd St. and A. V. R. R., Pittsburgh, Pa. Booths 126, 158.

Pipe line construction with details of fittings and joints, also photographs of installations in power plants. Welded headers, pipe expansion bends, line welds and examples of special joints for high pressure work.

PLIBRICO JOINTLESS FIRE BRICK Co., 1800 Kingsbury Ave., Chicago, Ill. Booths 133-4.

Here will be found several features, first a section of boiler furnace wall lined with jointless Plibrico furnace lining; second continuous moving picture entitled, Fighting Furnace Failures, showing the installation of Plibrico while plastic with a mallet and then baking out by the first heat of fire to give monolithic lining. Adaptability of Plibrico to water walls will be shown by a model section.

WM. A. POPE Co., 26 N. Jefferson St., Chicago, Ill. Booth 85.

Heating specialties and high pressure piping construction, also illustrations of piping systems of the company's erection.

THE PORTER-CABLE MACHINE Co., Syracuse, N. Y. Booth 234.

In this space the main feature will be an exhibit of two portable electric hand tools, the Take-About sander for surfacing and the Kwicksaw. Other equipment shown will be a combination belt sander and grinder and a Hevy-Du-T Universal milling attachment.

THE WM. POWELL Co., 2521 Spring Grove Ave., Cincinnati, Ohio. Booths 230-1.

Special educational features will be presented, showing the complete processing from foundry to finished products of bronze, iron and steel valves. There will also be a special large lot of steel valves, both hand and electrically operated, showing all the series from 150 to 900 lb. working steam pressure. Included in the exhibit will be a comprehensive line of bronze, iron and steel globe, angle, check and safety valves; oilers, lubricators, grease cups, oil and water gages and whistles.

THE POWER PLANT EQUIPMENT Co., Coca Cola Bldg., Kansas City, Mo. Booth 412.

Here will be shown three feature products, including Marley spray cooling equipment, steam superheater and steam purifier. The Marley superheaters are made for return tubular boilers with features designed particularly for such adaptation; purifiers are available for all standard sizes of boilers, the purifier being located outside the boiler.

POWER PLANT SPECIALTY Co., 440 S. Dearborn St., Chicago, Ill. Booth 40.

As the main feature of this company's display will be found a chemical feeder for water softening purposes, together with large size mounted blueprints showing the conventional arrangement of the company's water softeners.

THE POWERS REGULATOR Co., 2720 Greenview Ave., Chicago, Ill. Booth 451.

Featured at this booth will be thermostatic temperature control and regulators; other apparatus included will be hot and cold water mixers, steam traps, and dial indicating thermometers.

HENRY PRATT Co., 2222 S. Halsted St., Chicago, Ill. Booths 46-7.

Main feature in this display will be a complete Phillips expansion joint and another feature will be a coal spout swinger shown in operation.

PUBLIC SERVICE Co. OF NORTHERN ILLINOIS, 72 W. Adams St., Chicago, Ill. Booth 203.

A booklet of special interest to manufacturers considering middle west locations will be distributed by the Industrial Development Department of the company, showing the importance of the Chicago-Metropolitan district from the standpoints of marketing, transportation and labor supply. Also mineral and agricultural resources of the Great Lakes basin and the Mississippi Valley. Importance of reliability and continuity of electric power and gas supply will be shown and their value as economic factors in successful plant location. Maps, pictures and statistics will assist in giving a picture of the opportunities in this great industrial area. Additional features of the exhibit will be photographs of the developments of the constituent companies of the Public Service Co. of Northern Illinois.

QUIGLEY FURNACE SPECIALTIES Co., 26 Cortland St., New York, N. Y. Booths 13-14.

As a main feature this display will have the use of Hytempite illustrated by motion pictures shown on three portable continuous projectors. The pictures will show proper mixtures and various uses of this cement for furnace construction and maintenance work, also for the making of special shapes and tiles. Another feature will be the

Quigley refractory gun for applying plastic materials at high velocity so that the operator can reach any place in walls or arches. The gun can be used for Portland cement, whitewash, plaster stucco and similar materials. Triple-A solutions which are acid, alkali and water proof as used for protective coating on concrete, steel, brick and other surfaces will be demonstrated, and an acid proof cement which is for use in bonding masonry exposed to acid film.

RAMSEY CHAIN CO., INC., Albany, N. Y. Booth 24.

Representative display of sprockets, pinions and chains will be shown in two operating exhibits, one consisting of a large panel showing nine different sized sprockets, each having a freely suspended Ramsey silent chain. Motor drive will operate these sprockets at speeds of 1200 to 1500 r.p.m. showing the form which the chain assumes in operation and illustrating action of the roller bearing compensating joint construction. The second exhibit will be a large frame having a 27-tooth sprocket with a 12½ in. face on which will be suspended a chain 12 in. wide with 1 in. pitch and 94 links long, operated by a motor at a lineal speed of 3100 f.p.m. to demonstrate the smooth operation of the chain.

THE RAWLPLUG CO., INC., 66 W. Broadway, New York, N. Y. Booth 221.

Here will be shown Rawlplugs, Rawldrills and the Simbi electric hammer. The Rawlplug, a fibre screw anchor requiring but a small hole, the Rawldrill for masonry, drilling with fast cut, the electric hammer for percussion type drill.

READING STEEL CASTING CO., Bridgeport, Conn. Booths 187-8.

Facilities and methods for production, control, research and service of the company will be featured in a picture story in this display. There will also be shown specimens of larger size steel and iron valves, with motor operation, including cast steel gate valves and special Underwriters check valves and bronze valves.

REED AIR FILTER CO., 215 Central Ave., Louisville, Ky. Booth 450.

A Reed streamline automatic air filter will be shown in operation as a main feature of this exhibit, the filter being connected to a fan so that visitors can see exactly how it performs in regular service. In addition will be shown the Reed standard unit filter, compressor filters and high pressure filters for removing oil and moisture from compressed air lines. Part of the booth will be given over to Circulair Heat, a new type of convection heater for replacing cast iron radiators in steam and hot water systems.

REEVES PULLEY CO., Columbus, Ind. Booth 140.

Reeves variable speed transmissions will constitute the main feature of this display, all of new design, embodying improvements recently adopted.

THE RELIANCE ELECTRIC & ENGINEERING CO., 1042 Ivanhoe Rd., Cleveland, Ohio. Booths 326-7.

The main feature of display will be protective devices for electric motor insulations and windings; water and dust tight motors; also alternating and direct current motors with disassembled parts to show construction.

REPUBLIC FLOW METERS CO., 2240 Diversey Parkway, Chicago, Ill. Booths 70-73.

This company's exhibit will include a complete line of Republic instruments including steam flow meters, water meters, CO_2 meters, draft instruments, duplex and single record pyrometers, indicating pyrometers and liquid level indicators and recorders. As a chief feature will be shown a new type boiler meter panel, including a multiple recorder for six individual records on one wide strip chart, and a large animated cross section view of modern type boiler showing meter connections and points where readings are taken, to illustrate the relation between boiler records and efficient boiler operation.

RICHARDSON SCALE CO., Clifton, N. J. Booth 328.

Apron feed automatic crushed coal scale used for weighing direct from overhead bunker to a hopper of automatic stoker or pulverizer, illustrated by full size model, showing the method of weighing coal used by each individual boiler. Material is weighed and automatically discharged into a lower hopper which represents the supply for the furnace.

RISHER FIRE BRICK CO., 18th and Canal Sts., Chicago, Ill. Booth 89.

This company will exhibit a complete line of refractories consisting of high temperature cement, fire brick, fire clay and fire brick shapes and will also demonstrate its complete facilities for emergency supply of refractories in Chicago and vicinity.

ROWAN CONTROLLER CO., 431 S. Dearborn St., Chicago, Ill. Booth 314.

Automatic motor starters connected to motor-driven fan so that any of the starters can be used to start the fan equipment.

SARCO CO., INC., 183 Madison Ave., New York, N. Y. Booths 26-7.

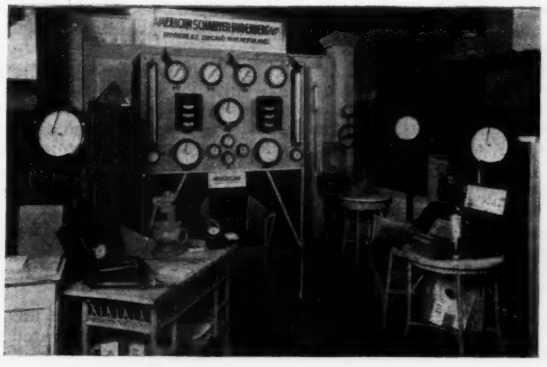
This company will show various types of steam traps for the industrial field, standard and special temperature regulators for hot water service tanks, industrial processing, dry kilns and so forth. It will also show a special line of regulators for refrigeration work, suitable for temperatures from zero upwards. As a special feature will be shown a complete Sarco heating line, including inlet valves, thermostatic traps and other apparatus for low pressure, vacuum and vapor heating systems.

SAUERMAN BROS., 438 S. Clinton St., Chicago, Ill. Booths 18-19.

This company's exhibit will include a working model of a power scraper installation for storing and reclaiming coal on an area adjacent to a power plant. Motion pictures will also show typical illustrations.

SCHUTTE & KOERTING CO., 12th & Thompson Sts., Philadelphia, Pa. Booth 60.

Here will be found spur and herringbone gear pumps, stop and check valves, piston valves, a steam jet thermo compressor, oil cooler, water jet eductor, double tube injectors, a complete line of jet appliances for handling liquids, heating liquids and handling air and gases. As the main feature, the display will have a herringbone gear pump in operation connected with a water jet eductor.



SHEPARD ELECTRIC CRANE & HOIST CO., Montour Falls, N. Y. Booth 329.

Standard LiftAbout hoist and close clearance hoist as made by this company will be shown in operation as the main feature. Large display frames will show photographs of installations and applications of the company's line of hoisting equipment from ¼ t. to 30 t. capacity.

D. H. SKEEN & CO., 362 Monadnock Block, Chicago, Ill. Booths 77-79, 103, 332-3.

This company is manufacturers' representative in the Chicago territory for the Air Preheater Corp., Allen-Sherman-Hoff Co., Dampney Co. of America, Dust Recovery, Inc., Edward Valve & Mfg. Co., Rolland Gardner Co., Henszey De-Concentrator Co., M. W. Kellogg Co., Mercon Regulator Co., National Co., Tri-Lok Co. Products exhibited will be, for the Air Preheater Corp., a scene-in-action photograph of the Ljungstrom air preheater, with models of complete boiler plants; for Allen-Sherman-Hoff Co., two scene-in-action pictures showing the operation of the hydrojet system for removing ash from boilers and also for carrying ashes to a sump and delivering to truck; for Dampney Co., a complete line of Apexior protective coatings for metal surfaces and the equipment designed for applying it to internal surfaces of boiler and economizer tubes; for Dust Recovery, Inc., dust collectors and method of their operation; for Edward Valve & Mfg. Co., a full line of forged steel valves showing latest developments for higher pressures and temperatures, including offset body and pillar type yoke construction; for Rolland Gardner Co., a non-segregating coal distributor; for Henszey De-Concentrator Co., a system of continuous blowdown with complete thermal recovery of the heat in the blowdown and the amount of blowdown being regulated in proportion to the amount of impurities; for M. W. Kellogg Co., full size samples showing latest developments in the manufacture of piping material for high pressure steam serv-

ice, also Dean high pressure power-operated parallel slide and swing gate valves; for Mercon Regulator Co., standard lines of pressure regulators without weights and constant excess pressure regulator for use in conjunction with any type of boiler water level controllers; for National Co., water column illuminator with light directed upon the water column and reflected by the top of the water so that the level is visible from all points on the operating floor; for Tri-Lok Co., ventilated steel flooring and safety steps for stairways; of its own manufacture, D. H. Skeen & Co., will show governors, regulators and valves and special power plant equipment.

S. K. F. Industries, Inc., 40 E. 34th St., New York, N. Y. Booths 38-39.

Transmission equipment of all kinds will be the principal feature of this exhibit with novel mechanical devices to show graphically advantages of the company's ball and roller bearings under severe operating conditions. A scenic background will cover the back of the booths, consisting of a large Neon sign with the company's trademark letters illuminating the booth and flashing colored lamps to call attention to a large painting in the center arch of the background, demonstrating the many flags under which the company's bearings are sold and used.

Skidmore Corp., 1535 Dayton St., Chicago, Ill. Booth 120.

Vacuum pumps for condenser and heating systems, diaphragm vacuum control and magnetic time limit.

M. B. Skinner Co., 558 Washington Blvd., Chicago, Ill. Booth 15.

Pipe repairs and saddles will constitute the main feature in this exhibit in which will also be included valve reseating tools and Bibb cock reseaters.

Standard Oil Co., 910 S. Michigan Ave., Chicago, Ill. Booth 159.

Here will be found as a main feature power plant lubricants, including steam cylinder oils, Diesel engine oils, air compressor oils, steam turbine oils and other lubricants for power and industrial machinery. There will be also a small display of motor oils for small apparatus and automobiles.

Stannard Power Equipment Co., 925 Monadnock Block, Chicago, Ill. Booths 83-4.

This booth will be in the form of a reception room where literature will be found covering the company's line of American steam pumps, deep well power heads, centrifugal pumps, Ric-Wil underground steam conduit for hot water, steam and oil pipe insulation.

Stephens-Adamson Mfg. Co., Aurora, Ill. Booth 209.

JFS variable speed transmission will be demonstrated in this booth and its application for the driving of industrial machinery and power plant auxiliaries. There will also be shown a general line of conveyors, elevators and crushers for power plant and industrial work.

Strom Ball Bearings Co., 4535 Palmer St., Chicago, Ill. Booth 23.

The display will include Super-Strom radial single and double row ball bearings, also angular contact, adapter type and thrust bearings shown by moving exhibit. Demonstration of the use of bearings on industrial machinery.

The Strong Scott Mfg. Co., 413 S. Third St., Minneapolis, Minn. Booth 186.

A model Unipulvo unit pulverizer will be the main feature of this exhibit embodying latest improvements and called "the 1928 model." Framed photographs will also be shown illustrating the installation and appliance of this unit.

B. F. Sturtevant Co., Hyde Park, Boston, Mass. Booths 205-7.

Main features of this exhibit will be the company's type I. D. induced draft fan and its plate and tubular type preheaters. The forced draft fan has alloy steel blades and heavy plates and air preheaters are of plate type with removable and reversible chambers. Tubular air preheaters are made with lead coated tubes. Other features of the exhibit will be stage blowers, coal burning blowers for household furnace work, Windovane fans for household ventilation and unit ventilators.

The Superheater Co., 17 E. 42nd St., New York, N. Y. Booths 127-8.

This company's exhibit will include enlarged sectional elevations of boilers with Elesco superheaters for a number of recent power plants. The designs will be for pressures up to 385 lb., temperatures to 735 deg. and capacities up to 500,000 lb. of steam an hour from a single unit. Section of the new eccentric Elesco superheater header will be shown, designed to operate at 1400 lb. pressure and 735 deg. temperature, these designs showing the tendencies in power plant construction and representing problems that are being solved by the company's engineers.

The Swartwout Co., 18511 Euclid Ave., Cleveland, Ohio. Booths 52-3.

This company will feature high pressure feed water regulators and the S-C type F feed differential valve for varying excess water pressure to each individual boiler. The exhibit will also show Swartwout steam traps, steam, oil and air separators, cast iron exhaust heads, feed water heaters, rotary ball-bearing ventilators, return and lifting traps, S-C feed water regulators, boiler feed pump governors, master control reducing valves, drainage controls, differential pressure valves, relief valves and heat controls.

W. O. & M. W. Talcott, Inc., 91 Sabin St., Providence, R. I. Booth 336.

Safety belt fasteners will be the feature of this exhibit, including the Talcott clinching belt fasteners and special conveyor belt fasteners for rubber, canvas and textile transmission belts from ⅛ to 1 in. thick and of every width, also the regular fasteners for leather belting and general use. Photographs and tests will be exhibited showing breaking strain of fasteners in leather and rubber belting and a new spring steel type fastener demonstrated for insertion between the middle plies of a rubber or canvas belt running over and under alternate pulleys.

The Terry Steam Turbine Co., Hartford, Conn. Booth 422.

Equipment to be exhibited here will include the following: a 150-hp. Terry wheel turbine designed for 200 lb. steam pressure and 50 lb. back pressure, suitable for driving pumps, generators, fans, pulverizers and the like; a complete rotor of a 500-kw. turbine suitable for driving an alternating current generator, of multi-pressure type and for operation against any back pressure up to 125 lb.; this may also be employed with slight alterations for bleeder or mixed pressure operation; a standard flexible shaft coupling in section, made from steel forgings and suitable for connecting all types of power equipment.

The Texas Co., 332 S. Michigan Ave., Chicago, Ill. Booths 428-9.

Texaco Industrial oils for all purposes and methods of manufacture and use will be illustrated in this booth.

Thomas Pump Co., 37 W. Van Buren St., Chicago, Ill. Booth 468.

Main feature of the display in this booth will be a Quimby screw pump with motor drive, pumping oil against 500 lb. pressure. Other equipment shown will be an Aurora cellar drainer, double suction centrifugal pump, Westco high head pumps in operating and a Pulsometer steam pump.

The Timken Roller Bearing Co., Canton, Ohio. Booths 414-5.

This company's exhibit will consist of bearings of the type used in railway journal boxes, also the type used on steel mill roll necks, of both single and double row bearings for electric motors and a general assortment of bearings suitable for use on power plant machinery of all kinds.

The Trane Co., La Crosse, Wis. Booths 143-4.

Heat cabinets showing the use of heating apparatus concealed inside the wall, in operation to show the method of installation and of the working of the cabinet; also visible type heating cabinets for use in place of the usual steam or hot water radiator.

The Tri-Lok Co., 5555 Butler St., Pittsburgh, Pa. Booths 332-3.

For this display the main feature will be the reproduction of a boiler room walkway and stair treads floored with Tri-Lok ventilated flooring and safety steps. Other features will be a shake-out table for foundry use, a sample of concrete floor armoring, a Tri-Lok flush type sidewalk or transformer vault door, as used by light and power companies and a sample of Tri-Lok approved by the Board of Transportation for ventilated openings in the sidewalks of New York City; also complete line of samples of different sizes, styles and depths of Tri-Lok of standard manufacture.

Troy Engine & Machine Co., Troy, Pa. Booth 197.

In this booth will be displayed a small type SH engine fitted with special glass panels to show the operation of the lubricating system and motion of the admission valve. Various working parts will be shown separately to demonstrate the details of construction.

Uehling Instrument Co., 423 Getty Ave., Paterson, N. J. Booth 149.

Apex meter showing fuel wasted up the chimney by recording CO_2 percentage and flue gas temperature on one chart. Also combined barometer and vacuum recorder.

THE UNISHEAR CO., INC., 270 Lafayette St., New York, N. Y. Booths 416-7.

This company will exhibit its entire line of metal cutting tools for cutting straight lines, curves and complicated designs either in outside or inside patterns in capacities from ¼-in. down to No. 14 U. S. plate. These devices work out forms which would be impossible without an extensive amount of hand labor by any other process.

UNITED CONVEYOR CORP., 800 Old Colony Bldg., Chicago, Ill. Booth 194.

In this exhibit the main feature will be a pneumatic ash conveyor system as installed in actual practice in plants. There will also be shown a steam jet ash conveyor system, cast iron ash tank, hard glazed tile ash tank and air-tight cast-iron ash pit doors.

VASTINE SALES CORP., 205 W. Harrison St., Chicago, Ill. Booth 208.

Ten models will be shown of Vastine fire observers, including large and small wall types, door types for both natural and forced draft, ignition model for installation at points where ignition of fuel takes place, model for installation with air-cooled walls, locomotive model and special model for use with water-cooled walls.

HENRY VOGT MACHINE CO., 10th and Ormsby Sts., Louisville, Ky. Booths 424-5.

The company's regular line of drop forged steel valves and fittings for high pressures will be shown, also special designs as used in refineries and central stations. Part of the space will be taken up with a boiler exhibit featuring an electric sign of large proportions to show internal workings of the Vogt water tube boiler.

VULCAN SOOT CLEANER CO., DuBois, Pa. Booth 195.

Self-contained monel-trimmed Vulcan operating head, Ratchet operating head, Crodon corrosion-resisting blower elements and detail parts of blowers.

WALSH FIRE CLAY PRODUCTS CO., 4070 N. Main St., St. Louis, Mo. Booth 201.

High temperature clays for mortar, fire brick, tile, blocks and special shapes, high-grade non-shrinkable refractories; clays and high alumina mixture.

THE WALSH & WEIDNER BOILER CO., Chattanooga, Tenn. Booths 176-7.

In this exhibit will be found the following material: Longitudinal section of the latest type 54-in. steam drum for 450 lb. working pressure with heads shrunk on outside of ends of the shell, high pressure manhole and other special features; also two standard high-pressure forged steel sectional headers for 500 lb. working pressure and one for 1600 lb.; in addition a section of the Walsh & Weidner special entire covered water wall, a new special high pressure water gage and cross sections of various parts of the company's equipment; working model will be shown of the 4-drum bent tube water tube boiler of the company's manufacture.

WALWORTH CO., Boston, Mass. Booths 98-9, 100-1.

Walworth Sigma valves and fittings for high pressures and temperatures and a novel exhibit of the company's Stillson wrench will be features of this display. The central feature of the steel valves will be a motor-operated Sigma gate valve for 900 lb. working pressure and other features will be gate, globe and check valves for various pressures. To demonstrate the perfect metal in the castings, a sectioned 8-in. steel tee with risers cast integral will be shown. In the wrench display will be a unique testing device of a 14-in. wrench mounted on a pipe in a vise with 6 ft. length of pipe arranged to bring a knife-edge load to bear at the end of the wrench handle. A man putting his weight on the pipe brings tremendous pressure on the wrench.

WARREN WEBSTER & CO., Camden, N. J. Booths 41-2.

In this exhibit will be found Webster systems of steam heating and the equipment for such systems, together with series 78 traps and No. 026 drip traps. Also will be displayed Webster Type R systems with the latest developments for all these systems.

WEBER INSULATIONS, INC., 148th and Railroad Ave., E. Chicago, Ind. Booth 235.

Industrial insulation for power and industrial plants will be the main feature of this display, which will also include insulations for house piping and house construction.

THE WELLMAN-SEAVER-MORGAN CO., 7000 Central Ave., Cleveland, Ohio. Booths 113-14.

As a main feature, this display will have Wellman supertest gate and globe valves, which are designed for exacting requirements and for highest pressures and temperatures in modern steam plants, oil refineries, pipe lines and in hydraulic air and gas lines of industry. Seats are an integral part of a valve cage, this valve cage having external takeup adjustment to compensate for expansion or extraction. The cage may be utilized to shut off flow through the valve while repairs or adjustments are being made. Other products of the company will be illustrated by photographs.

WESTINGHOUSE UNION BATTERY CO., Swiftdale Station, Pittsburgh, Pa. Booth 223.

This company's exhibit will consist of heavy duty batteries for control bus application in central and sub-station and for general power use. Pressed glass jars and heavy insulation in all batteries will be special features, individual cells of various sizes being shown; also an assortment of wood case types and standard connections and jumpers. Small model of a central station battery installation will be exhibited.

WESTON ELECTRICAL INSTRUMENT CORP., Newark, N. J. Booth 305.

The feature of this display will be a new type of the Weston model 44 electric tachometer and the company will also exhibit a representative group of both panel and portable types, alternating and direct current instruments.

C. H. WHEELER MFG. CO., Lehigh and Sedgley Aves., Philadelphia, Pa. Booths 94-5.

Main features of the exhibit will be a three-stage Radojet air pump, arranged with three stages in series with inter condensers between first and second and between second and third stages, as used for vacuum above 29.2 in. Also a two-stage Radojet air pump with combined surface inter and after condenser, having the water in the hot or condensate section flowing around vertically arranged tubes, while in the cold water section, circulating water flows through the vertically arranged tubes. Another feature will be the Leach Fracto-control condenser which gives means for close separation of several distillate fractions, allowing adjustment and control of the cooling mediums in various vapor compartments. A cross section model of the two-stage Radojet air pump will also be shown with drawings and photographs of condenser installations and auxiliaries.

THE WICKES BOILER CO., Saginaw, Mich. Booth 446.

This exhibit will consist of a lantern slide machine showing shop operations used in the construction of boilers, as well as views of actual installations. In addition a section of a Wickes patented single joint header used in horizontal cross drum boilers will be shown, and a model of the new Wickes three-drum curved tube boiler with photographs of installations. Descriptive literature will be available.

L. J. WING MFG. CO., 352 W. 13th St., New York, N. Y. Booth 318.

A Wing turbine blower will be shown of the type used to supply forced draft to both stokered and hand-fired boilers by installation directly in the boiler wall and delivering individual forced draft to each boiler. A motor-driven blower will also be shown supplying forced draft to low pressure heating boilers and a centrifugal turbine blower for supplying air in excess of 6 in. water pressure, these blowers being used for supplying the blast to gas producers and for pulverized coal burning. Another feature will be a Wing featherweight unit heater as used for heating industrial buildings and others of the wide-area type, also a Wing Scruplex exhauster for removing heated air, fumes, gases and other mixtures from which the motor should be protected.

WORTHINGTON PUMP & MACHINERY CORP., 115 Broadway, New York, N. Y. Booths 48-9.

Main features of the display will be a set of steam jets mounted over inter and after cooler as used in large power plants to illustrate the action in removing noncondensable gases from condensers. Other equipment shown will be a special high pressure oil line centrifugal pump and two smaller centrifugal pumps.

WRIGHT-AUSTIN CO., 315 W. Woodbridge St., Detroit, Mich. Booth 435.

This company's exhibit will cover the standard line of separators, water columns and steam traps which it manufactures, emphasizing particularly the Airxpel bucket trap. Kleervu gage glass protector will be shown as it was last year, also the Crescent try cock. All these products are comparatively new.

YARNALL-WARING CO., Chestnut Hill, Philadelphia, Pa. Booths 43-4.

Here will be found a full line of Yarway blowoff valves for pressures up to 1350 lb.; also working model of a Yarway spray pond equipped with involute spray nozzles and fittings. First showing will be made of Yarway high and low pressure water columns with Sesure inclined water gages. Other products shown will include the Lea V-notch meter, hydraulic valves, pipe joint clamps and Holtite pipe clamps.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Two New "Ideal" Products

TWO NEW products have recently been placed on the market by the Ideal Commutator Dresser Co. of Sycamore, Ill. One of these is the Ideal portable electric blower, shown in Fig. 1, which is designed for blowing dust out of motors, switchboards, generators, line

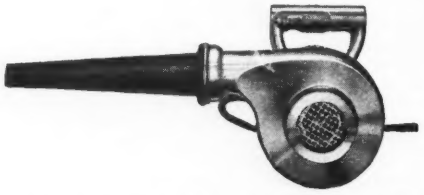


FIG. 1. THE IDEAL COMBINATION BLOWER AND SUCTION DEVICE

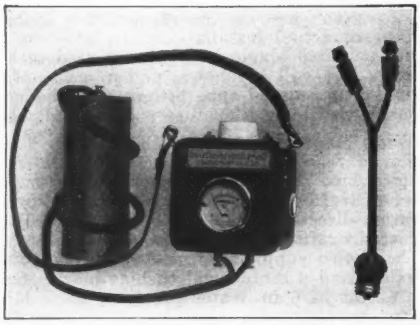


FIG. 2. THE IDEAL SHORTFINDER

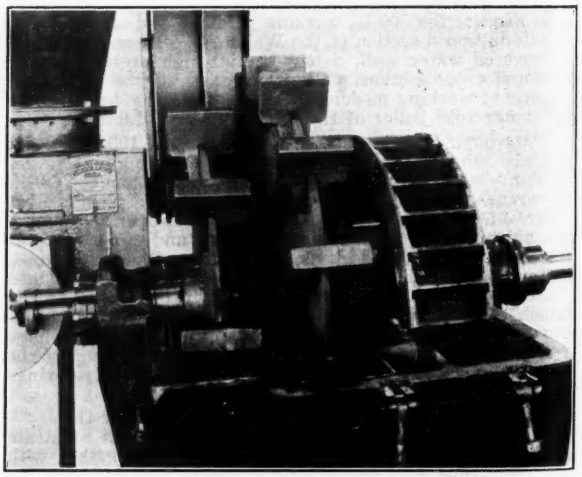
shafting and other factory equipment. It can be plugged into any electric light socket and is complete in itself. With the addition of simple attachments, this blower may also be used as a vacuum cleaner to remove dust and dirt from stock bins, girders, etc. When used as a vacuum cleaner in connection with grinding commutator or slip rings, it prevents dust from entering the windings. For this particular use, 4 ft. of 1¼-in. diameter rubber hose is provided and also a dust bag which is emptied by simply removing the clip at the bottom.

Another recent product of this company is the "Shortfinder" shown in Fig. 2, which quickly locates short circuits in wiring without the necessity of disconnecting any wiring or disturbing any fixtures. It is a rugged instrument, light in weight, that is carried on a strap slung over the shoulder of the operator. A battery used in connection with it is an ordinary dry cell.

When the instrument is connected to a dead short circuit and the push button pressed, the indicator will read zero. In practice the zero point will usually be found to be 2 points above the zero mark, due to the slight resistance offered by the connecting leads. In testing for a short circuit in a line, attachment is made either by the plug or clips, and a reading taken. The nearer to the short circuit the nearer the reading will be to zero. In practice, a full scale deflection will occur if the test is made 50 or more feet from the short circuit; 3 to 6 in. away will be indicated by a reading of about 3 divisions. Should the short circuit be in a concealed place, such as in conduit, the exact location can be estimated from the value of the readings taken on either side of the short.

Warrior Unit Pulverizer Is Announced

THE FUEL EFFICIENCY ENGINEERING CORP., Birmingham, Alabama, has recently developed and placed on the market a new line of coal pulverizers, known as the Warrior unit pulverizers, as shown here-



WARRIOR PULVERIZER EMPLOYS TWO PULVERIZING STAGES

with. The complete line includes units of 200 to 15,000 lb. per hr. capacity, designed for use both on boilers from 100 hp. up and in connection with fuel fired furnaces such as are used for metallurgical, ceramic or other industrial heating work. They are designed for direct connection to the boiler or furnace to be supplied, no intermediary conveying systems being required.

The units which make up the line consist of a two stage pulverizer, with automatic feed and delivery

mechanism, directly driven by a motor or steam turbine mounted on the same base. The pulverizer proper is divided vertically into four compartments, separated by split diaphragms, two of which contain the pulverizing paddles, one the auxiliary air chamber, and the fourth a fan which serves the double purpose of drawing the pulverized coal through the compartments and delivering it to the burners. The lower half of the pulverizer shell, together with the main shaft bearing pedestals, is cast integral with the base for rigidity and strength. The upper half is removable in two units, one over the pulverizing chambers, the other over the fan and auxiliary air chamber.

The two pulverizing compartments are furnished with removable steel liners, made in four sections and jigged to facilitate easy removal and replacement. The pulverizing paddle wheels and the fan are all keyed to an alloy steel shaft, which is mounted in Timken bearings. The discs are driven from the hub by shearing bolts which will release them in case material which cannot be pulverized gets into the chamber and fails to be caught by the tramp iron pocket in the first stage.

Feed mechanism consists of a rotary plate feeder, driven by a variable speed friction disc from the main shaft of the machine. Both the plate and disc shafts are mounted on Timken bearings adjusted to hold them rigidly in alinement so as to preserve the proper relations between the various contacting members of the drive. The feeder drive is equipped with a simple and accurate means of adjustment for different rates of feed which may be arranged for automatic operation if desired.

United Engineers and Constructors Incorporated Is Formed

ACCORDING to a statement issued by Arthur W. Thompson, president of The United Gas Improvement Co., the largest engineering and construction company in this country has been organized in Philadelphia. "Four firms, widely known in this and other countries, have combined their interests and organized the United Engineers and Constructors, Incorporated," said Mr. Thompson. "These companies are The U. G. I. Contracting Co., Philadelphia, the Public Service Production Co., Newark, Dwight P. Robinson & Co., Inc., New York, and Day & Zimmermann Engineering & Construction Co., Philadelphia. Headquarters of the new company will be in Philadelphia, with offices in New York, Newark, Chicago, Los Angeles, Atlanta, Houston, Pittsburgh, Montreal, Buenos Aires and Rio de Janeiro."

Dwight P. Robinson is president of the company. The directors are Arthur W. Thompson, president of The United Gas Improvement Co., chairman; Dwight P. Robinson; Thomas N. McCarter, president, Public Service Corp. of New Jersey; Samuel T. Bodine, chairman, board of directors, The United Gas Improvement Co.; Paul Thompson, a vice-president of The United Gas Improvement Co. and president of the Philadelphia Gas Works Co., and John E. Zimmermann, president of Day & Zimmermann, Inc. The new company is launched with contracts in hand amounting to more than $100,000,000.

With the work now under way, including the construction of large dams for the Government on the Ohio River, extensive hydro-electric development on the Housatonic River, Connecticut, important work in South America and Spain and large office and apartment buildings in New York and other cities, the United Engineers and Constructors, Incorporated, starts business with an unusual program.

Important Papers for Winter Convention of A. I. E. E.

AN AMERICAN INSTITUTE of Electrical Engineers convention of outstanding interest and importance is promised in the program planned for the 1928 meeting, which will be held February 13-17 with headquarters at the Engineering Societies Building, New York City.

Technical papers and lectures will include as subjects dielectrics, operation of interconnected power systems, insulators, magnetism, electrical machinery, communication, automatic substations, control and protective apparatus, synchronizing devices and arc welding. Great interest is being manifested in the session on Tuesday morning, February 14, on the subject of operating interconnected power systems. This subject will be presented in papers by five outstanding engineering executives, representatives of different practices in five parts of the country.

Telephone communication with the British Institution of Electrical Engineers, meeting simultaneously in London, is to be one of the outstanding features of the convention. This event is scheduled for Thursday morning, February 16, and will open with two papers on transatlantic telephony. Following these papers there will be an exchange of greetings over the New York-London radiotelephone circuit between Bancroft Gherardi, President of the American Institute of Electrical Engineers and Archibald Page, president of the British Institution of Electrical Engineers. Officers of the respective telephone systems in the two countries will also exchange greetings. Arrangements are being made for these exchanges of greetings to be heard by those present at the session of the A. I. E. E. in New York, and also by the members of the Institution of Electrical Engineers, who will be having a regular afternoon meeting in London simultaneous with the New York meeting.

Dr. Harold Norinder of Upsala, Sweden, well known in this country for his studies of lightning discharges and other matters, will furnish one of the interesting points of the meeting. He will deliver a lecture in the session on the afternoon of February 14, his subject being "The Cathode Oscillograph as Used in the Study of Lightning and Other Surges on Transmission Lines."

Another event will be a lecture on "The Earth's Electric Charge," to be given by Dr. W. F. G. Swann on Monday evening, February 13. Dr. Swann, who is Director of the Bartol Research Foundation of the Franklin Institute, is an entertaining speaker as well as a high authority on subjects pertaining to electrophysics.

Two of the most highly desired rewards for engineering accomplishment will be presented on the evening of Wednesday, February 15. The John Fritz Medal will

be presented to General John J. Carty and the Edison Medal to Dr. William D. Coolidge.

Quite a number of inspection trips have been planned, most of which will be taken on Thursday afternoon, February 16, though some of the places may be visited at other times by prearrangement. Among the trips which are planned are those to the following places:

132-kv. cable installation at Hell Gate Station of the New York Edison Co.

"Iron-clad" switchgear—a substation of the New York Edison Company having only this enclosed type of construction.

System operators switchboard, Waterside Station, New York Edison Co.

220-kv. switching station—Hudson Station of Public Service Electric & Gas Co.

Hudson Avenue Station of Brooklyn Edison Co.

Broadcasting studio of National Broadcasting Co.

A-c. network switches of United Electric Light & Power Co.

The Electrical Testing Laboratories.

The Bell Telephone Laboratories.

The annual dinner dance will be held on the evening of Thursday, February 16, in the main ballroom of the Hotel Astor and an informal smoker will be held on Tuesday evening, February 14.

News Notes

AT THE TWENTY-THIRD annual meeting of the American Society of Refrigerating Engineers in New York, held December 5 to 7, 1927, George B. Bright of Detroit, Mich., was elected president of the society. H. D. Edwards of New York City was elected vice president and David L. Fiske, editor of Refrigerating Engineering, was elected secretary.

Mr. Bright has been connected with the refrigerating field for many years, having installed the first raw water ice plants for Pittmans & Dean Co. in Detroit. For several years he has conducted his own refrigerating engineering business. In February of 1922 he installed the first "can-basket" plant in this country.

J. A. MOORE, Chicago, was elected president of the Illinois Society of Engineers at the 43rd annual meeting of the society in its three-day quadriennial session at the University of Illinois, Champaign, Ill. Other officers are: Prof. M. L. Enger, head of the department of theoretical and applied mechanics, vice president; A. J. Shaffmyer, Chicago, and G. H. Rightor, Springfield, directors. Chicago was designated for the next meeting. Among the speakers were: Prof. A. C. Willard, head of the department of mechanical engineering; Prof. A. C. Callen, head of the department of mining engineering; George Rippetoe, vice president and general manager of the Anna Stone Co.; F. E. Gault, manager of the commercial department of the Central Illinois Public Service Co.; J. E. Lamar, geologist for the Illinois State Geological Survey in charge of the non-fuel products division. Excursions through the university laboratories were features of the sessions which are held here every four years.

THE CAROLINA POWER & LIGHT CO., Raleigh, N. C., has purchased the South Carolina Power & Light Co., with headquarters at Kingstree, S. C., and the transmission systems of the two companies will be interconnected.

NATIONAL CARBON CO., INC., Carbon Sales Division, Cleveland, Ohio, announces the opening on January 3, 1928, of branch sales offices as follows: 357 W. 36th St., New York, in charge of E. C. Friday; 551 W. Monroe St., Chicago, in charge of J. L. Green; Arrott Power Bldg., 3 Barker Place, Pittsburgh, Pa., in charge of V. J. Nolan; 1824 Ninth Ave., Birmingham, Ala., in charge of J. B. Collins. J. A. Hammond has been appointed assistant manager in charge of carbon brush and specialty sales at Cleveland and E. R. Geib has been appointed manager in charge of sales of illuminating carbons, also at Cleveland.

WM. B. SCAIFE & SONS CO., Oakmont, Pa., has recently received an order from the Carnegie Steel Co. for a water softening system for the Duquesne Works at Duquesne, Pa. The softened water will be used for boiler feed and a total of 8,000,000 gal. a day will be the ultimate capacity. The system will be of the intermittent type, wherein the water will be treated and allowed time for reaction and sedimentation in four 540,000-gal. tanks, each equipped with stirring devices and indicating and recording gages. After the water is softened it will pass through eight concrete filters, each of a capacity of 1,000,000 gal. a day. Electrically operated valves and hydraulically operated valves will be used for remote control of the flow to the various tanks, while indicators and recorders give complete information on the cycle of operation, all pumping equipment being automatically controlled.

THE PUBLIC SERVICE CO. of New Hampshire, Manchester, N. H., has arranged for the purchase of the power rights and plant of the Salmon Falls Mfg. Co., Salmon Falls, N. H. Plans are proposed for transmission line construction to connect the various districts with the present main lines.

THE GULF STATES STEEL CO., Birmingham, Ala., plan to install a 20,000-kw. generating plant in connection with the electrification of its mill at Alabama City. Dwight P. Robinson & Co., Inc., 125 E. 46th St., New York, is engineer in charge.

THE AMERICAN GAS & ELECTRIC CO., 30 Church St., New York, is making plans for a 232,000-v. transmission line from Churchtown, N. J., in connection with its proposed power plant on the Delaware River. Stevens & Wood, Inc., is engineer.

W. S. MERKLE, 414 North Twelfth Blvd., St. Louis, Mo., consulting engineer, has preliminary plans under way for a hydroelectric project in the south central part of Missouri, for a company whose name is temporarily withheld, to cost about 2½ million dollars.

JAMES R. WHITE, for nine years vice-president of Rickard & Co., New York, industrial advertising agency, on Jan. 1 became secretary of Jenkins Brothers, 80 White Street, New York.

THE LYNN GAS & ELECTRIC CO., Lynn, Mass., will soon begin construction of a boiler plant estimated to cost close to $800,000. Stone & Webster, Inc., is engineer.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wisconsin, announces that beginning January 1, 1928, its Pacific Coast sales will be handled by its own Pacific Coast sales offices. These are at 970 Folsom St., San Francisco; 229 Boyd St., Los Angeles; 2203 First Ave., South, Seattle, Washington. The new sales district will be in charge of Fred H. Oberschmidt, A. A. Tuffert and George P. Stone will be associated with him. Thomas N. Bristow will be in charge of the Seattle office and Edward G. Nelson of the Los Angeles office.

R. H. BEAUMONT CO., 319 Arch St., Philadelphia, Pa., announces that Wm. P. Alexander, who resigned from this organization last May has returned to its Sales Department. Beaumont Mfg. Co., Philadelphia, Pa., announces that its former chief engineer, L. O. Hassler, has been transferred to its western headquarters, Straus Bldg., Chicago, to engage in sales work in that territory under direction of H. E. Birch.

AT A RECENT MEETING of the Board of Directors of Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, it was announced that P. C. Brooks has been elected a vice president. Mr. Brooks has been connected with the organization for 29 yr. in many positions of responsibility. In addition to his present office, he is president of E. & T. Fairbanks & Co. and vice president of the Canadian Fairbanks-Morse Co., Ltd.

DEATH OF GEORGE W. MATHEWS, for many years superintendent for the Foundation Co. of New York, occurred Jan. 3 in Pekin, Ill., where since March 1, 1927, he had been in charge of work upon the power plant under construction there for The Superpower Co. Mr. Mathews was ill with pneumonia a week. He was a native of New York. So successful had been his management of the Pekin project that he was far ahead of of his schedule when he was stricken. The body was returned to New York for funeral services and burial.

J. E. LEWIS, president of the Harbison-Walker Refractories Co., Pittsburgh, Pa., has been elected a director of the American Arch Co. of New York. The American Arch Co. owns a large block of Harbison-Walker stock and it is believed that the former company will soon have representation on the Harbison-Walker board.

THE NUGENT STEEL CASTINGS CO., Chicago, Ill., announces that George L. Pollock, vice president and treasurer of the Burnside Steel Foundry Co. since its organization, has resigned as of January 1 to become vice-president of The Nugent Steel Castings Co.

LINCOLN ELECTRIC CO., Cleveland, Ohio, announces a new motor in sizes ½ to 30 hp., for 2 or 3-phase current at 60 cycles, and to operate without starting device. It has high starting torque and high pull out torque at overloads, low temperature rise and is of welded steel construction.

REFERRING TO PRESS REPORTS of an explosion in the plant of Northern States Power Co. in St. Paul, Minn., on the afternoon of January 3, Robert F. Pack, vice-president and general manager, made the following statement:

"Shortly before 3 o'clock in the afternoon of January 3, there was an accident to the No. 2 generator at the High Bridge Station in St. Paul, putting this unit out of commission. With the exception of very minor injury to two employes, no persons were injured and no damage was done to any property other than the company's. The plant was slightly damaged by fire, but the entire loss is fully covered by insurance. Service was interrupted in some sections of St. Paul for approximately half an hour. Speedy resumption of the service was made possible due to the interconnection of different plants of the Northern States Power system into the power loop that surrounds the Twin Cities. There is ample generating capacity to supply all requirements until repairs to the damaged generator can be made."

HAROLD A. THOMAS, professor of hydraulics in the department of civil engineering at the Carnegie Institute of Technology, has been appointed hydraulic engineer for the City of Pittsburgh to make a study of flood heights as affected by various proposed changes on the water fronts. His work for the city will be primarily concerned with studies of flood heights in relation to construction changes recommended by the City Planning Commission and similar agencies.

TROY ENGINE & MACHINE CO., Troy, Pa., announces that A. R. McMahon of that company was the winner of a gold watch as first prize offered in the D. O. James Speed Reducing Guess Contest held at the Sixth New York Power Show last December. C. W. Derr of L. C. Biglow Co., New York, won second place and J. N. Taddiken of Taddiken & Co., Forest Hills, L. I., N. Y., was third.

CARL H. CASBERG, superintendent of the machine laboratory at the University of Illinois, Champaign, Ill., has been appointed manager of the shop laboratories, effective Feb. 1. He fills the vacancy caused by the death of Bruce W. Benedict. The appointment is effective February 1.

APPOINTMENT OF TWO additional staff officers of the National Electric Manufacturers Association, 420 Lexington Ave., New York, is announced by Alfred E. Waller, managing director. Engineering matters affecting the entire membership will hereafter be directed by W. J. Canada, formerly of the National Fire Protection Ass'n. Harold T. Melhuish will handle the increased association business of members of the N. E. M. A. Radio Division.

THE DEATH OF A. F. MESERVEY, aged 77 yr., general manager of the Fort Dodge (Iowa) Light and Power Co., occurred Jan. 3 in his home in Long Beach, Calif., where he had lived the last 12 yr. since his retirement from active life.

CENTRAL STATES ELECTRIC CO., Cedar Rapids, Ia., has retained the Fargo Engineering Co., 147 Mechanic St., Jackson, Mich., to prepare preliminary plans for a proposed hydroelectric plant on the Des Moines River near Ft. Dodge, Iowa.

THE T. G. TAYLOR CO., Portland, Ore., represented by Allen B. Engle, Dexter-Horton Bldg., Seattle, Wash., is planning the construction of a power house in connection with a proposed pulp and paper mill in this section.

PERMISSION HAS BEEN ASKED of the City Council of Tacoma, Wash., by Ira Davisson, Commissioner of Public Utilities to proceed with the construction of the second unit of the Cushman hydroelectric project, to involve an expenditure of about $4,000,000. The Com-

missioner proposes to start work immediately on a unit designed for capacity of 45,000 hp., which represents only about one-half of the second proposed unit of the project, which is to have a potential capacity of 70,000 hp. J. L. Stannard, chief engineer of the first Cushman construction work, will be in charge of the work on the second unit it is expected. His chief assistants are A. F. Darland, electrical engineer and J. V. Gongwer, structural engineer.

THE SAN ANTONIO PUBLIC SERVICE CO., San Antonio, Texas, is planning to install a 30,000-kw. turbo-generator unit at its Comal power plant. E. H. Kifer is vice-president and general manager.

CONSOLIDATED GAS & ELECTRIC LIGHT CO., Baltimore, Md., is reported to be planning an expansion program in its power plants and system during 1928 to cost about $6,000,000.00.

THE WISCONSIN POWER & LIGHT CO., Madison, Wis., has secured permission to construct and operate a hydro-electric plant on the Embarrass River in the vicinity of Embarrass, Wisconsin.

Books and Catalogs

"HEATING AND VENTILATION," a handbook for architects and engineers, by Charles W. Brabbee, translated and adapted from the seventh German edition of a book by Dr. H. Rietschel; cloth, 6 by 9 in., 332 pages, 187 illustrations, 24 tables and charts. McGraw-Hill Book Co., Inc. Price, $4.50.

In translating and adapting this text for American heating and ventilating engineers, Dr. Brabbee has abridged some portions of it which do not apply particularly to American practice and has emphasized other parts for convenience. While much of the equipment illustrated is of German manufacture, many types of American devices of the latest forms are shown. The German approach to the subject of heating and ventilating is along lines much more theoretical than the American, therefore the book contains more mathematical analysis of heating and ventilating problems than the American engineer is accustomed to. For this reason it should be of greater interest to designers of heating and ventilating systems than to operators, but for this purpose it provides much valuable information.

Several tables such as those for various types of heating systems are supplied in large sized charts inserted in a pocket in the back of the book so that they are large enough for use in practical work.

RILEY STOKER CORP., 9 Neponset St., Worcester, Mass., has just issued a 36-page, well-illustrated bulletin describing the Riley Super-Stoker.

IN THE Labor Saver for January, published by Stephens-Adamson Mfg. Co. of Aurora, Ill., appears an article on Timken roller bearing-equipped belt conveyors, showing their use for handling coal and other fuels over long or short distances. Applications of the J. F. S. variable speed transmission for industrial drives is the subject of another interesting article.

DESIGN of Furnaces for Pulverized Coal is the title of a pamphlet by Martin Frisch, engineer of the Combustion Engineering Corporation, 200 Madison Ave., New York City. Mr. Frisch discusses the combustion problem, importance of turbulence, flame speeds, air requirements, wall temperatures and effect of air preheating. Copies may be had by writing to the company.

EXPERIENCES WITH AUTOMATIC Combustion Control is the title of a paper by A. S. Davis, reprinted by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia. This narrates experiences with the new L & N metered combustion control as installed at the Manchester Street Station of the United Electric Railways Co.

HENRY VOGT MACHINE CO., Louisville, Ky., is issuing a bulletin describing the Vogt Class M water-tube boiler.

HARDINGE CO., York, Pa., describes the new Hardinge unit coal pulverizer in Bulletin No. 27.

TOLEDO PIPE THREADING MACHINE CO., Toledo, Ohio, in a recent folder shows the action of the new Toledo automatic pipe cutter.

ELECTRIC MACHINERY MFG. CO., Minneapolis, Minn., in bulletin 856 describes and illustrates synchronous motors for refrigerant compressors.

THE BETHLEHEM TORQUE AMPLIFIER and Bethlehem lashlock are described in recent bulletins issued by Bethlehem Steel Co., Bethlehem, Pa.

BADGER WELDED expansion joints are described and illustrated in a leaflet sent out by E. B. Badger & Sons Co., 75 Pitts St., Boston, Mass.

THE ELLIOTT single-stage, single-inlet blower of new design is described in a 4-page bulletin sent out by Elliott Co., Jeannette, Pa.

REEVES PULLEY CO., Columbus, Ind., in recent folders describes Reeves compact motor drive and Reeves electrical remote control.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., in leaflet 2094, describes the type SSU centrifugal pumping unit, in which the pump is mounted on the motor casing. These are for capacities up to 200 g.p.m.

TURBINE TYPE VALVES for control of equipment by automatic combustion controls are described in bulletin 39 by Smoot Engineering Corp., 136 Liberty St., New York, N. Y.

GRAYDON MANUFACTURING CO. has issued a 4-page folder discussing Graydon preheaters for exchanging heat in various industrial processes. These are made with heating surfaces from 2.7 sq. ft. of 1084 sq. ft.

ENGBERG'S ELECTRIC & MECHANICAL WORKS, St. Joseph, Mich., has issued bulletin 6023, covering Engberg constant and adjustable speed d.c. motors from 1 to 50 hp., and bulletin No. 6025, describing Engberg motor generators from 1 to 37½ kw.

GENERAL ELECTRIC CO., Schenectady, N. Y., in Bulletin GEA-517A, describes totally enclosed fan cooled d.c. motors, type CD from 2 to 51 hp., and in bulletin GEA-808, describes totally enclosed induction motors of the 500 series, new form R.

PENNSYLVANIA PUMP & COMPRESSOR CO., Easton, Pa., in a 16-page illustrated bulletin No. 209, describes Pennsylvania double suction, single stage centrifugal pumps. These are built in capacities up to 20,000 g.p.m. and for heads up to 290 ft. They are arranged for motor, turbine or engine drive as desired.